

AGENCY FOR HEALTHCARE RESEARCH AND QUALITY

AHRQ

AHRQ National Web Conference on Clinical Decision Support Efforts That Assist Clinical Cognitive Processes

Presented by:

A. Zach Hettinger, MD, MS, FACEP

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Yalini Senathirajah, PhD

Moderated by:

Roland Gamache, PhD, MBA, FAMIA

Agency for Healthcare Research and Quality

October 19, 2021

Agenda

- Welcome and Introductions
- Presentations
- Q&A Session With Presenters
- Instructions for Obtaining CME Credits

Note: You will be notified by email once the slides and recording are available.

Presenter and Moderator Disclosures

A. Zach Hettinger, MD
Presenter

Anping Xie, PhD
Presenter

Yalini Senathirajah, PhD
Presenter

Roland Gamache, PhD
Moderator

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- Panelist Disclosures: Dr. Hettinger, Dr. Xie, and Dr. Senathirajah have no relevant financial interests to disclose.
- Moderator Disclosures: Dr. Gamache has no relevant financial interests to disclose.
- AffinityCE, TISTA and AHRQ staff, as well as planners and reviewers, have no relevant financial interests to disclose.
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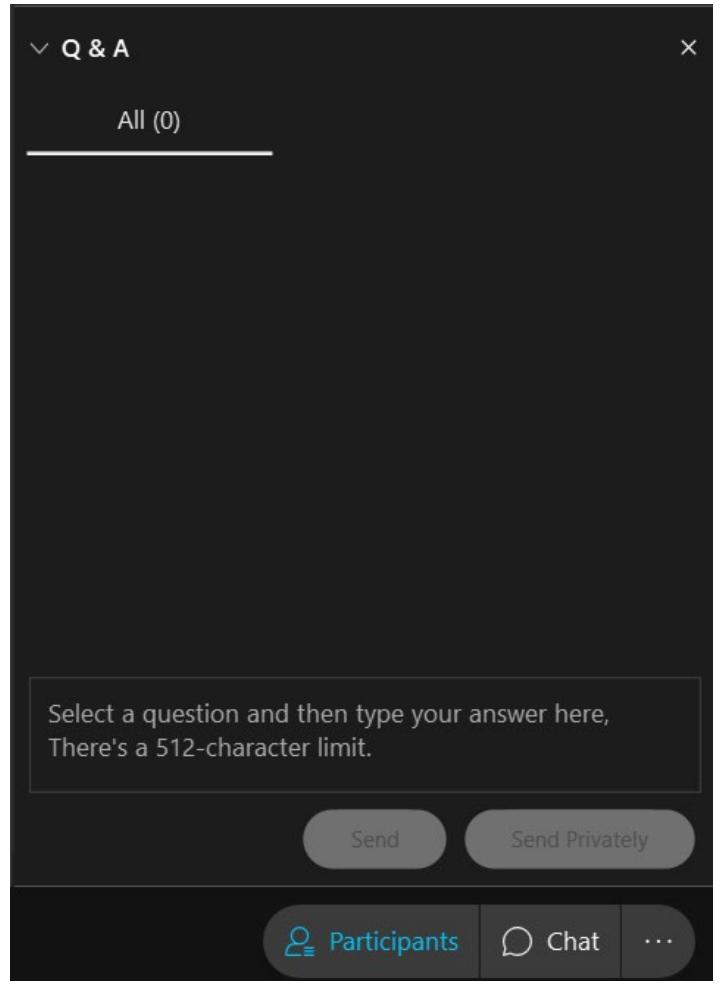
- At any time during the presentation, type your question into the “Q&A” section of your WebEx Q&A panel.
- Please address your questions to “All Panelists” in the drop-down menu.
- Please include the presenter’s name or their presentation order number (first, second, or third) with your question.
- Select “Send” to submit your question to the moderator.
- Questions will be read aloud by the moderator.



Learning Objectives

At the conclusion of this web conference, participants should be able to:

1. Describe the role of cognitive engineering for complex decision making and problem solving in acute care and understand the application of these tools as part of CDS development.

2. Explain and apply the strengths of analytical and naturalistic decision making in the design of effective CDS tools.

3. Review interaction design in electronic health records and how a ‘composable’ approach helps solve problems of display fragmentation and the related impact on clinical cognitive load and clinical reasoning.



AGENCY FOR HEALTHCARE RESEARCH AND QUALITY

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Applying Cognitive Support to the Emergency Department Using Human Factors Engineering

A. Zach Hettinger, MD, MS, FACEP, FAMIA

Director, MedStar Health Center for Biostatistics, Informatics, and Data Science

Director of Cognitive Informatics, MedStar Health National Center for Human Factors in Healthcare

Assistant Professor of Emergency Medicine, Georgetown University School of Medicine

Funding Disclosures

- **AHRQ (R01 HS22542 Cognitive Engineering for Complex Decision Making & Problem Solving in Acute Care)**
- General Research Funding
  - FDA
  - ONC
  - NIH
  - VA/DoD
  - PEW Charitable Trust/AMA

Learning Objectives

- Attendees will:
  - Obtain a brief primer on human factors engineering and potential value in healthcare
  - Appreciate the role of cognitive support and risk for errors
  - Review case examples of cognitive support in health IT systems



AHRQ

Brief Introduction To:

Human Factors Engineering

Human Factors Engineering (HFE)

- "Designing for human use"
  - Human-Machine Interface (display, control)
- Optimizes the relationship between technology and the human user
- Designs the system to match abilities
- Data-driven, evidence-based
- Normal in aviation, nuclear, military


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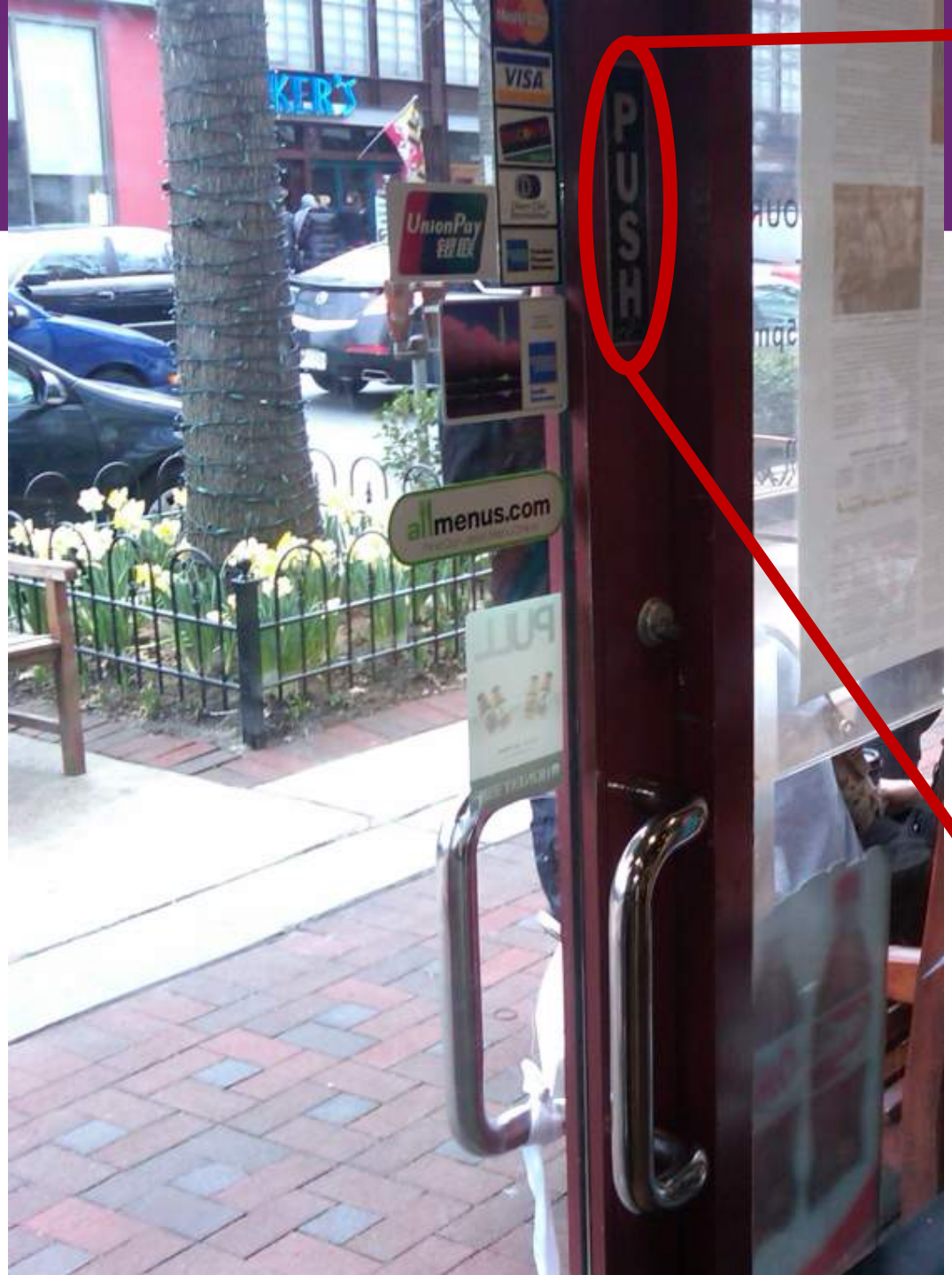
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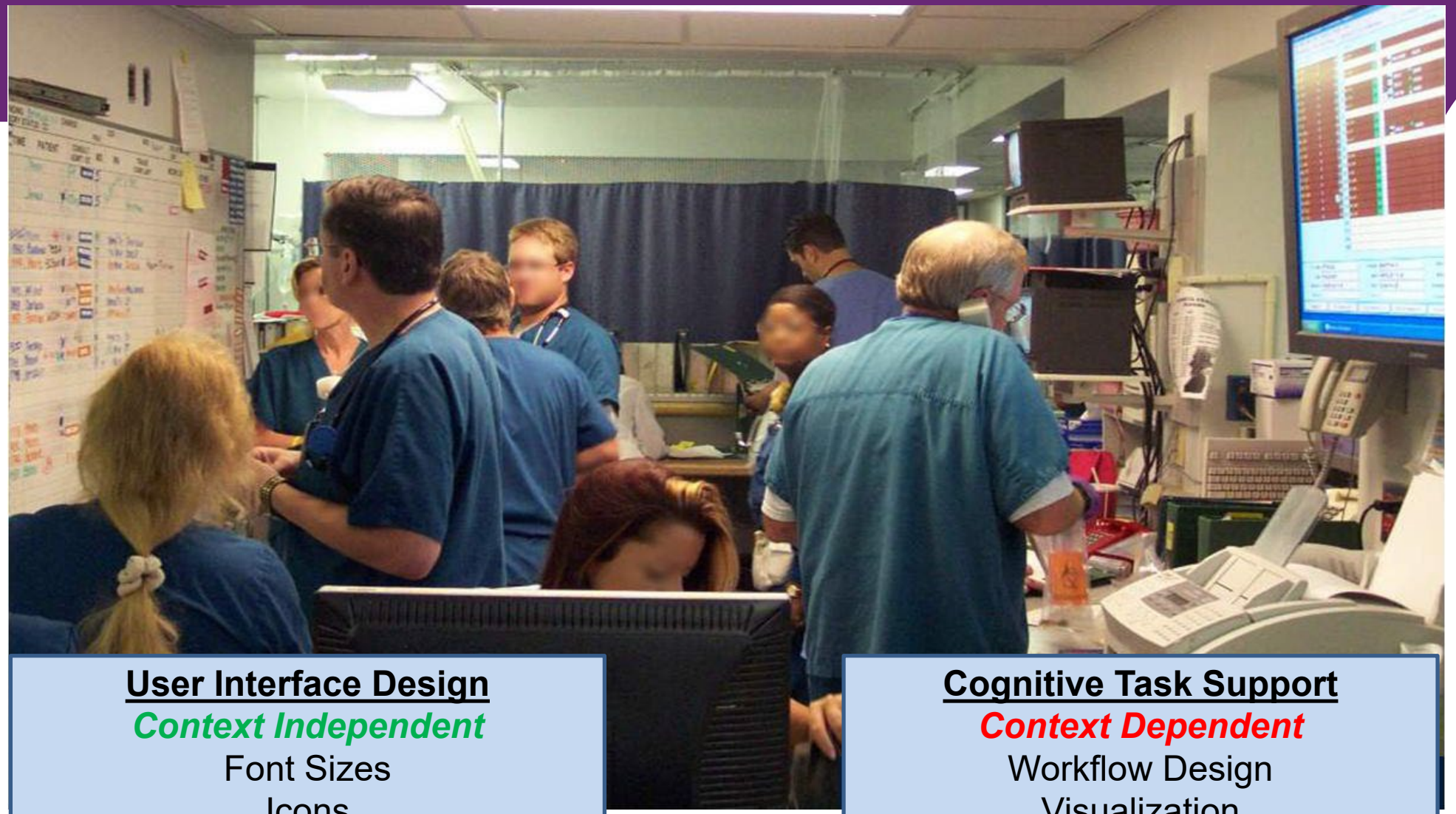
PUSH

Better Design – Push Bar


TO EXIT
PRESS HERE
PRESS
TO
OPERATE
DOOR
TO EXIT
PRESS HERE
PRESS
TO OPERATE
DOOR

Unexplained Apnea Under Anesthesia

https://psnet.ahrq.gov/web-mm/unexplained-apnea-under-anesthesia



User Interface Design

Context Independent

Font Sizes

Icons

Colors & Contrast

Layout

Cognitive Task Support

Context Dependent

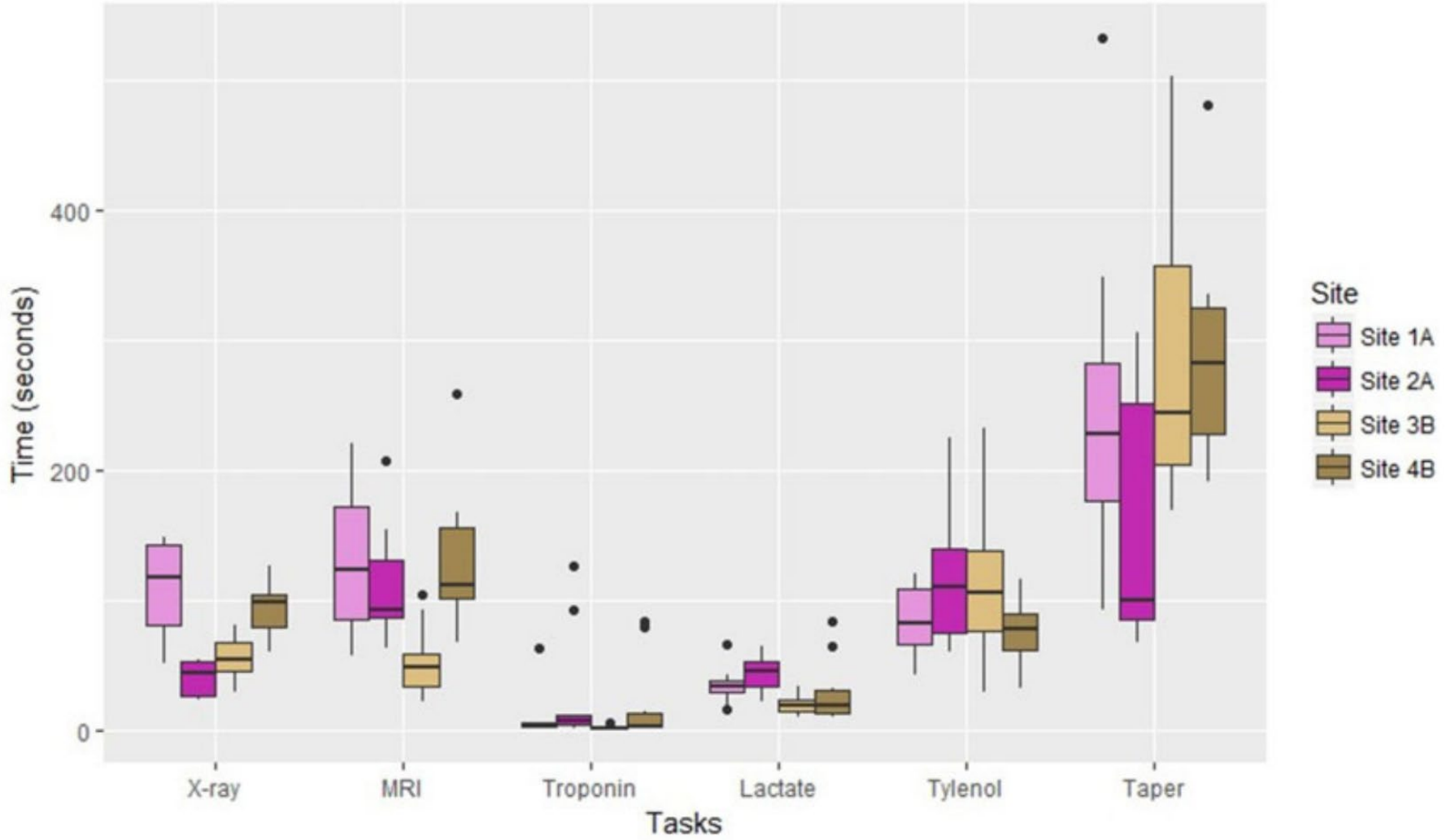
Workflow Design

Visualization

Memory Aids

Error Anticipation

Cognitive Task Support for Writing Orders



Ratwani RM, Savage E, Will A, Arnold R, Khairat S, Miller K, Fairbanks RJ, Hodgkins M, Hettinger AZ. A usability and safety analysis of electronic health records: a multi-center study. Journal of the American Medical Informatics Association. 2018 Jul 2;25(9):1197-201.

Table 2. Summary of duration, clicks, and accuracy

EHR functions	Usability and safety metrics	Site 1A Mean (SD)	Site 2A Mean (SD)	Site 3B Mean (SD)	Site 4B Mean (SD)
X-ray (left elbow, wrist, forearm)	Task duration (sec)	64.1 (22.4)	24.3 (8.5)	33.3 (9.9)	55.5 (13.3)
	Clicks	31.1 (12.6)	7.7 (3.8)	8.1 (4.9)	15.5 (6.6)
	Error rate	25%	16.7%	35.7%	20%
	Types of errors:				
	- *Wrong-site x-ray ordered*				
	- *Omission of one part of the order (eg, forearm)*				
MRI (cervical, thoracic, lumbar)	Task duration (sec)	78.9 (33.4)	66 (25.6)	32.2 (16.1)	79.5 (34.3)
	Clicks	28.9 (13.7)	22.4 (10.5)	14.2 (18.2)	33.3 (15.7)
	Error rate	0	8.3%	7.1%	10%
	Types of errors:				
	- *Omission of one part of the order (eg cervical)*				
Troponin	Task duration (sec)	5.3 (10.3)	14.2 (24.5)	1.5 (.9)	12.1 (19.7)
	Clicks	2.7 (2.9)	4.3 (9.4)	.9 (.9)	8.2 (16.3)
	Error rate	0	0	0	0
	Types of errors: *None*				
Lactate (timed order)	Task duration (sec)	20.4 (8)	26.9 (7.9)	12.1 (4.9)	17.5 (15.1)
	Clicks	9.9 (3)	11.1 (3.4)	6 (2.5)	6.6 (5.5)
	Error rate	0	0	14.3%	0
	Types of errors:				
	- *Ordered for wrong time*				
	- *Ordered unnecessary tests*				
Tylenol (500 mg PO, 4-6 hours)	Task duration (sec)	51.4 (15.3)	70.4 (32)	69.3 (38.2)	45.6 (15.9)
	Clicks	14 (4.1)	23.5 (15.8)	61.6 (94)	25.8 (11.2)
	Error rate	8.3%	0	7.1%	30%
	Types of errors:				
	- *Wrong dose, frequency, route, and rate*				
Prednisone taper (60 mg, reduce by 10 mg every 2 days for 12 days)	Task duration (sec)	148.6 (76.1)	152.7 (163.4)	175.1 (73)	178.7 (62.6)
	Clicks	32.2 (16.6)	20 (32.8)	42.3 (17.6)	28.2 (5.7)
	Error rate	16.7%	41.7%	50%	40%
	Types of errors:				
	- *Wrong dose*				

Ratwani RM, Savage E, Will A, Arnold R, Khairat S, Miller K, Fairbanks RJ, Hodgkins M, Hettinger AZ. A usability and safety analysis of electronic health records: a multi-center study. Journal of the American Medical Informatics Association. 2018 Jul 2;25(9):1197-201.

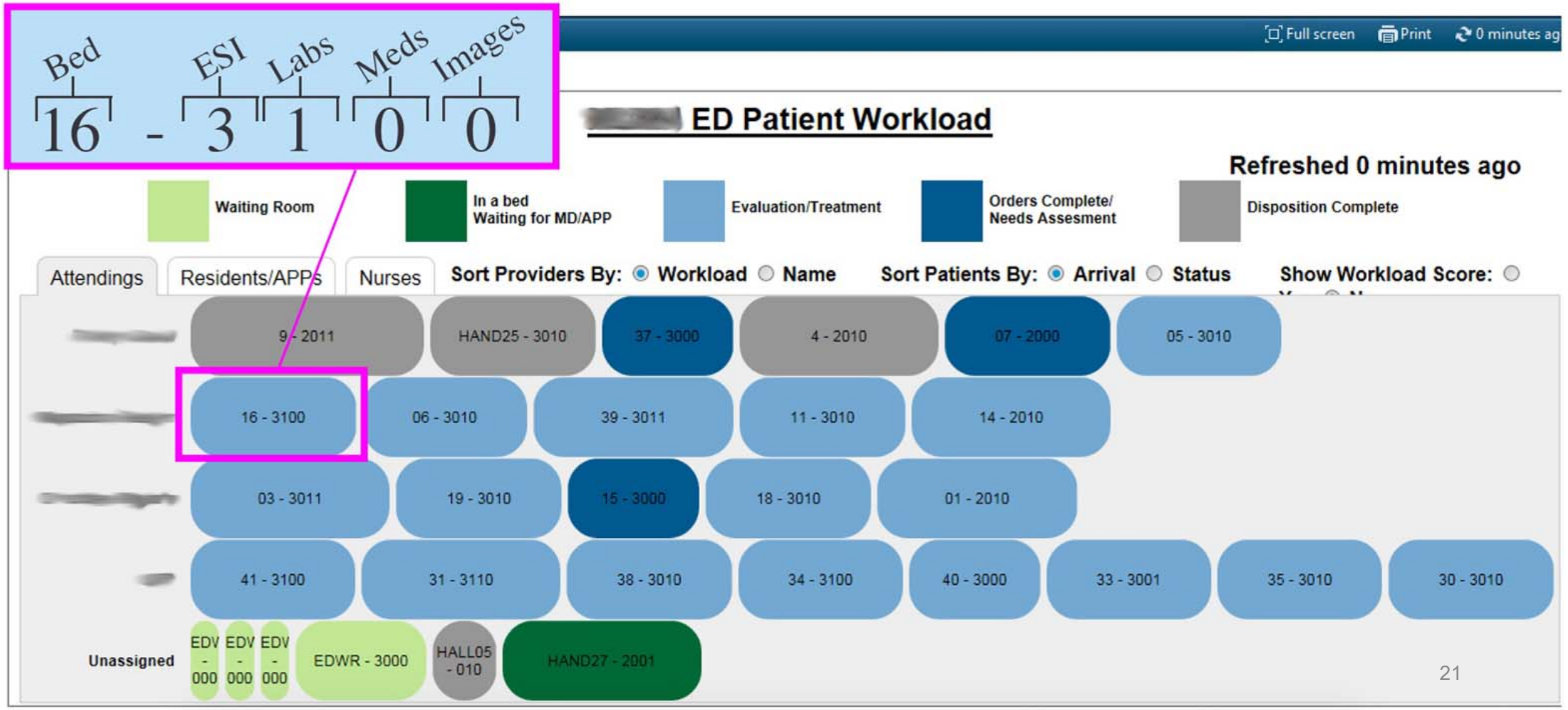


Providing Cognitive Support in the Emergency Department

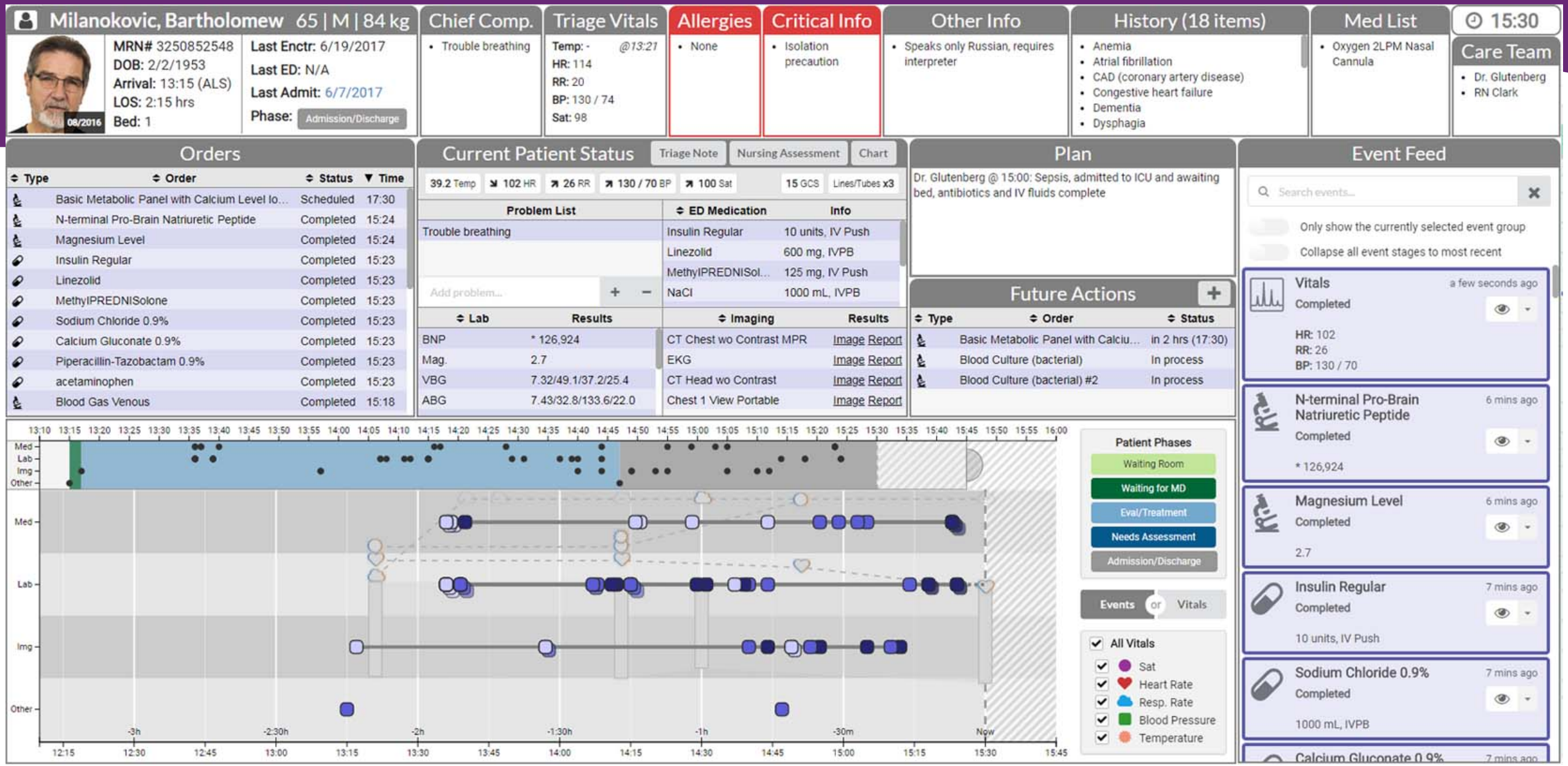
Cognitive Engineering for Complex Decision Making & Problem Solving in Acute Care

- Cognitive needs and decision making of nurses, physicians, and advance practice providers in the ED.
- Mixed Methods Approach:
  - Interviews & Focus Groups
  - Ethnographic Observations & Cognitive Task Analysis
  - EHR Data & Prototype Design

Cognitive Support - ED Triage/Workload

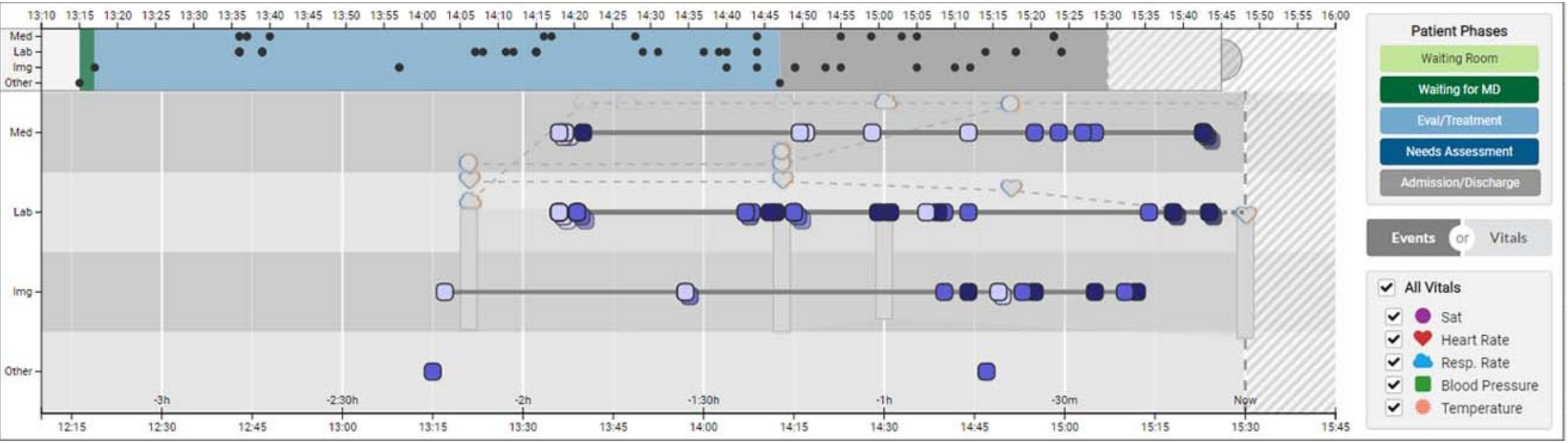


Cognitive Support - Time Ordered Events



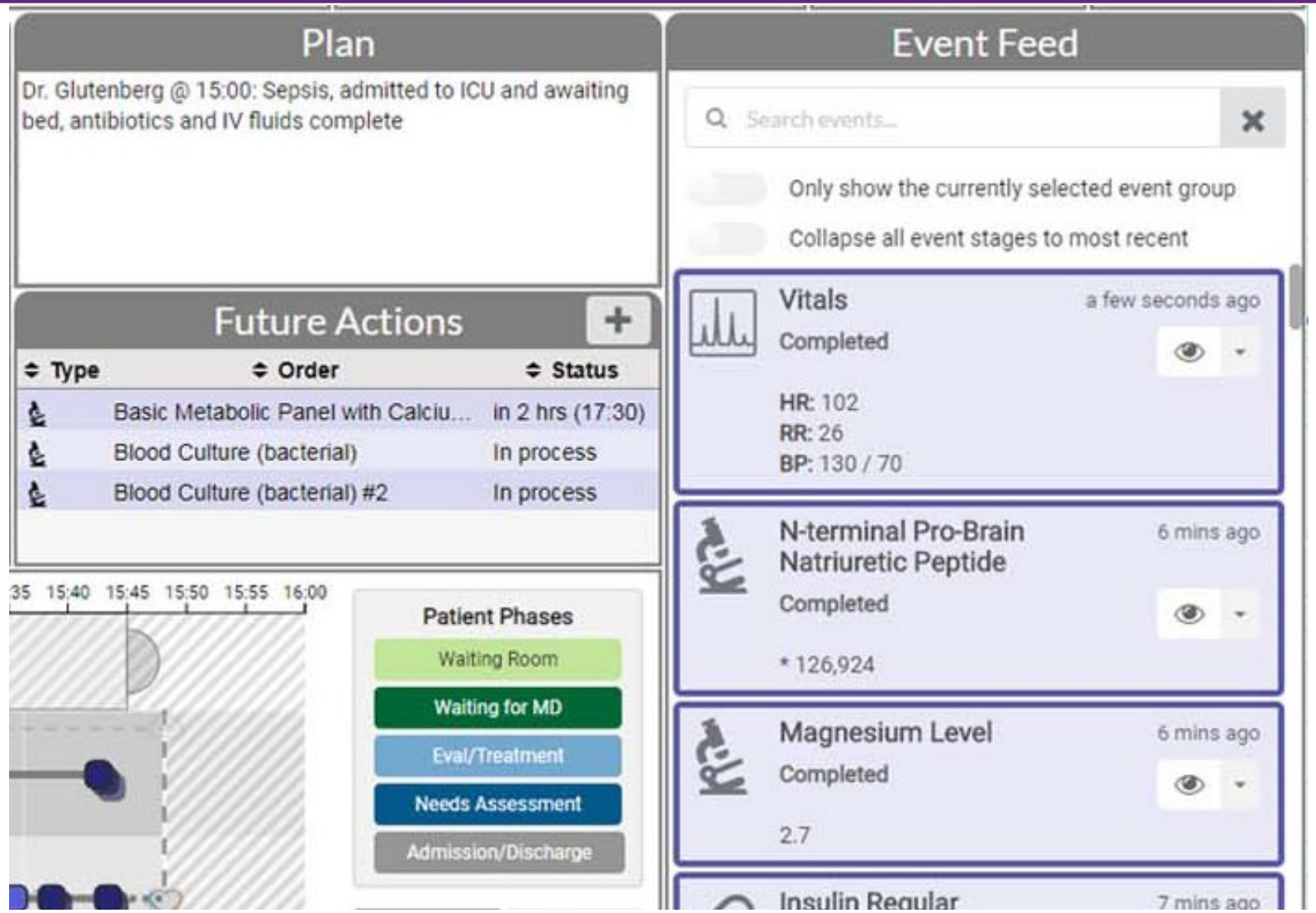
*Simulated Patient

Cognitive Support – Temporal Analysis



*Simulated Patient

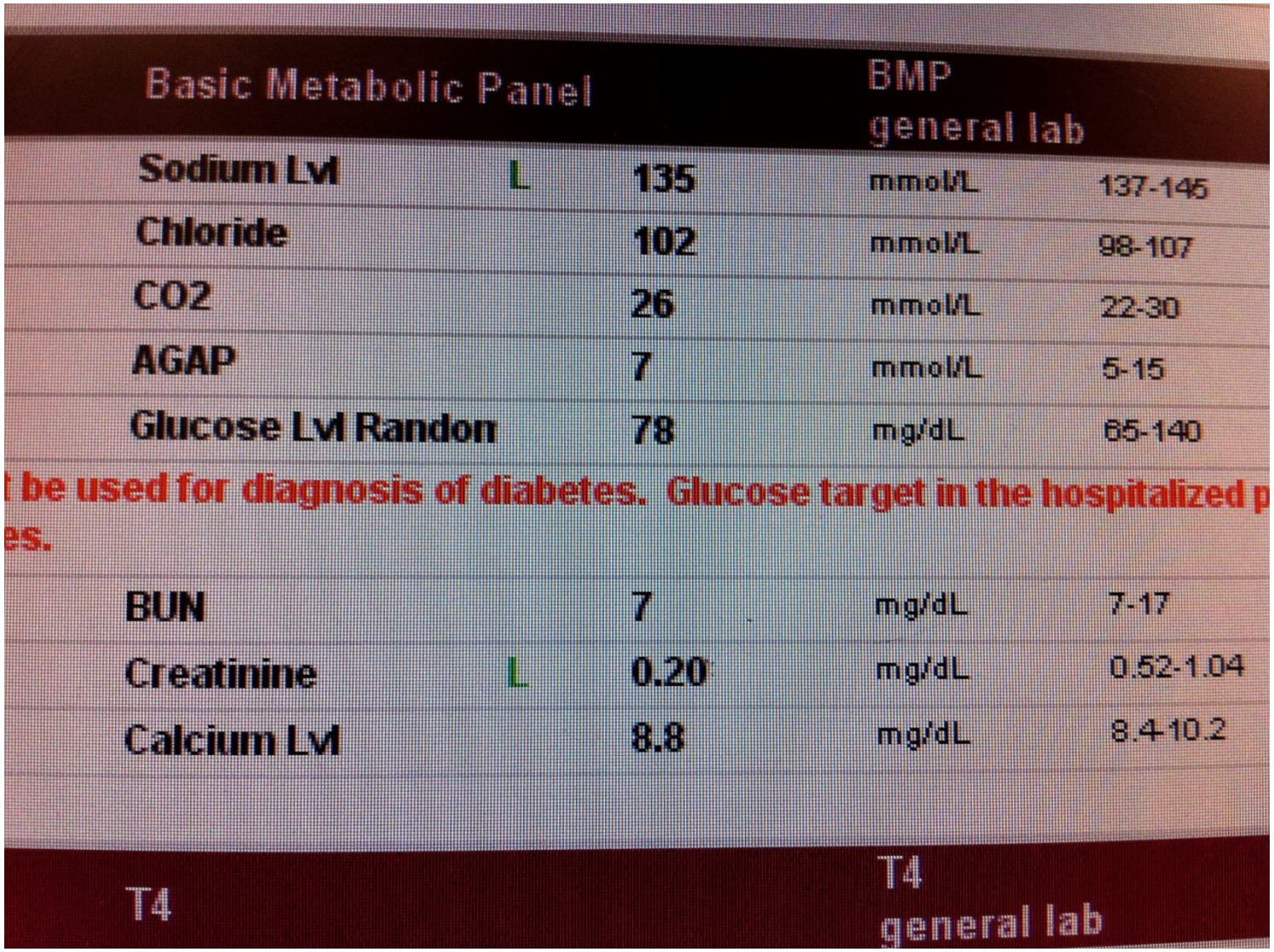
Cognitive Support – Team Communication





Poor Support Case Examples

Errors Happen if We Don't Support Cognitive Processes



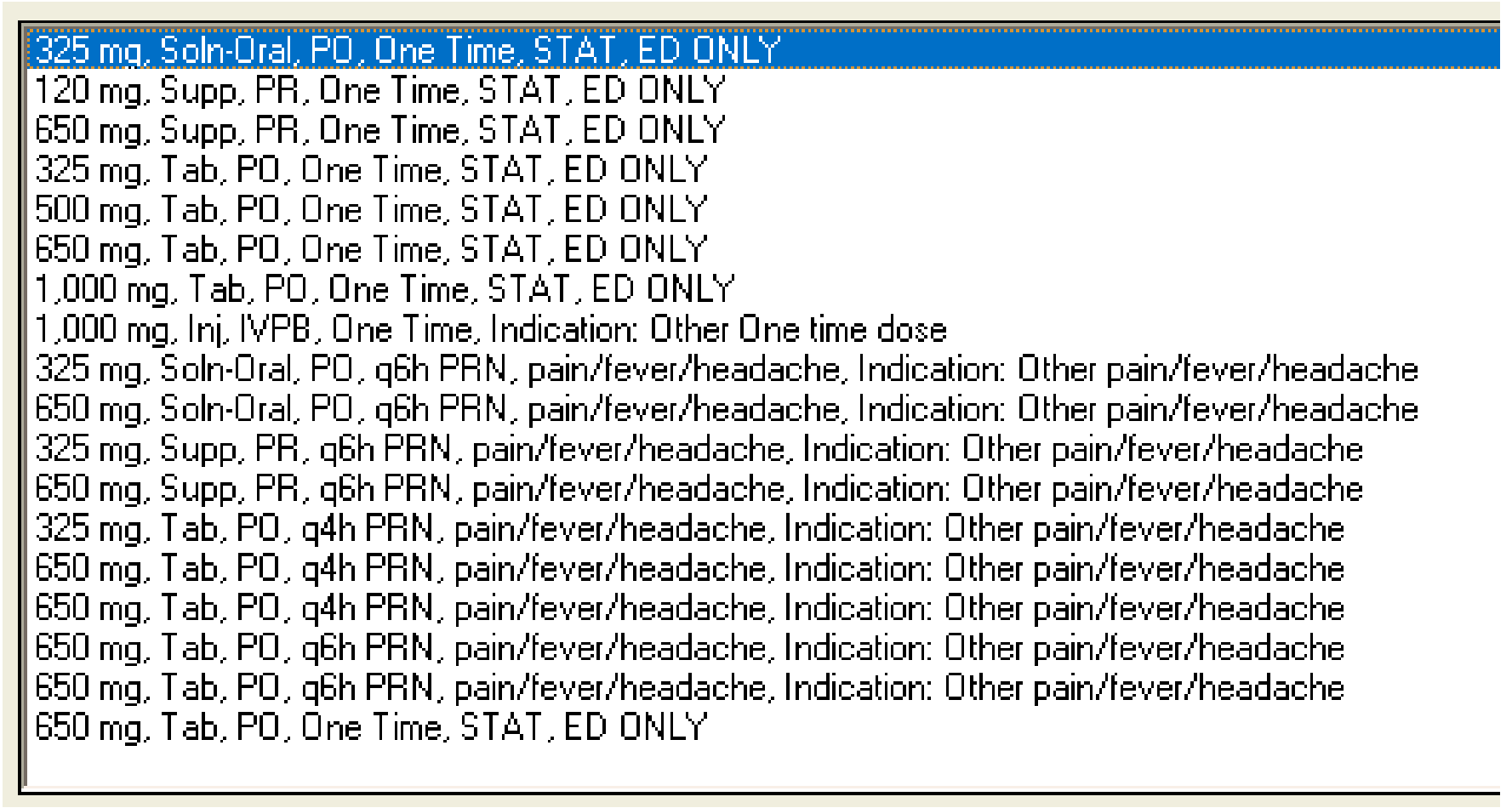
Basic Metabolic Panel			BMP general lab	
Sodium Lvl	L	135	mmol/L	137-145
Chloride		102	mmol/L	98-107
CO2		26	mmol/L	22-30
AGAP		7	mmol/L	5-15
Glucose Lvl Randon		78	mg/dL	65-140

t be used for diagnosis of diabetes. Glucose target in the hospitalized p
es.

BUN		7	mg/dL	7-17
Creatinine	L	0.20	mg/dL	0.52-1.04
Calcium Lvl		8.8	mg/dL	8.4-10.2

T4	T4 general lab

Health IT "Bloat" Causing Cognitive Strain and Lack of Cognitive Support



If you miss the difference between "O" and "R" the patient will remind you

Summary

- Brief primer on human factors in healthcare
- Cognitive support and potential for error
- Need for improved health IT systems and alignment with healthcare processes

Contact Information

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Cognitive and Macro Ergonomics in Clinical Decision Support Design and Dissemination

Anping Xie, PhD
Assistant Professor, Armstrong Institute for Patient Safety and Quality
Johns Hopkins School of Medicine

Objectives

- Brief introduction to the discipline of Human Factors and Ergonomics (HFE) and its domains of specialization

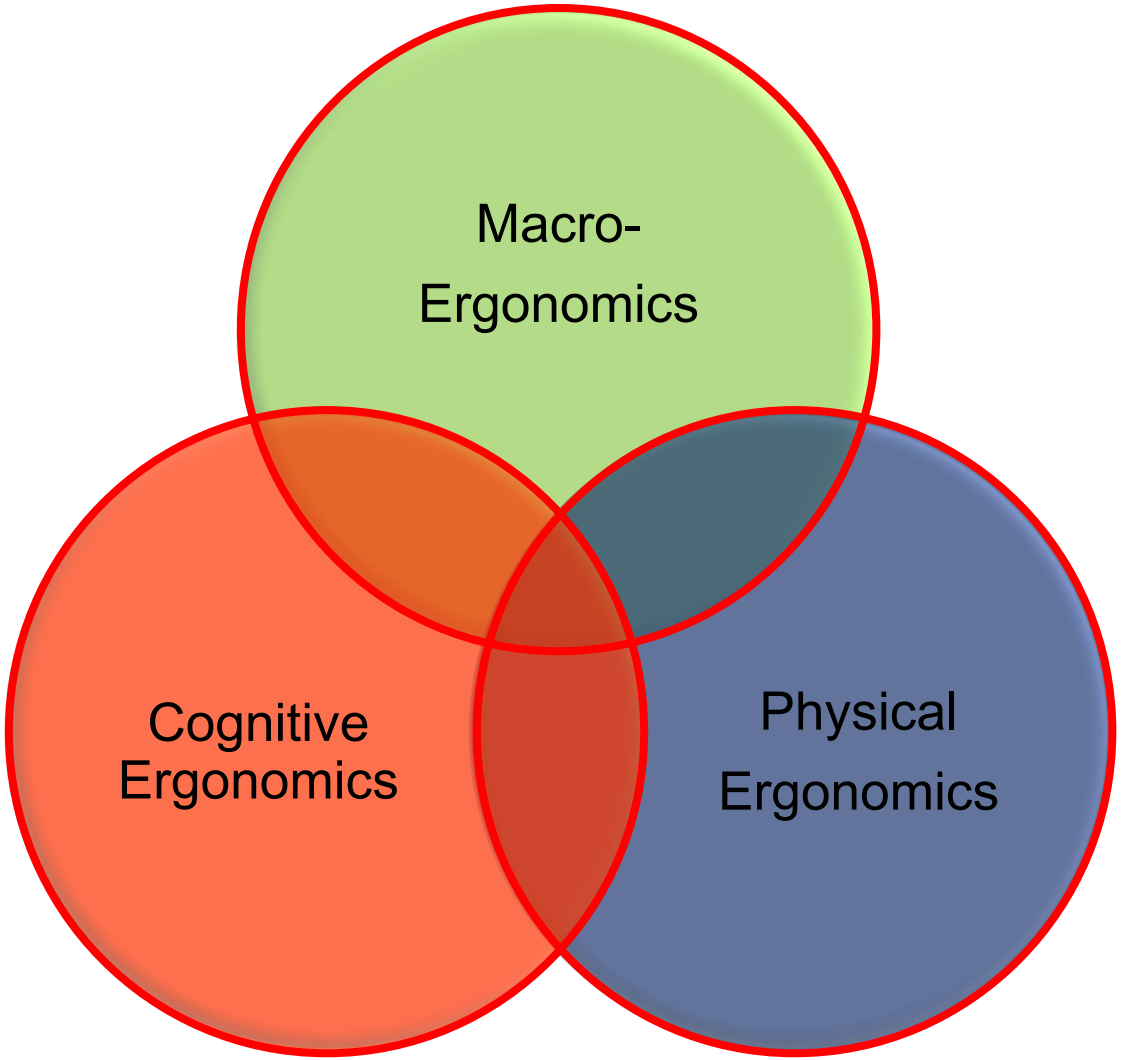
- An example of HFE application to the design and dissemination of CDS tool for blood culture decision-making in sepsis diagnosis
  - Cognitive ergonomics work informing the integration of CDS tool into EHR
  - Macro-ergonomics work informing the dissemination of CDS tool

Human Factors and Ergonomics (HFE)

"… the scientific discipline concerned with the understanding of **interactions among humans and other elements of a system**, and the profession that applies theory, principles, data, and methods to **design** in order to **optimize human well-being and overall system performance.**"

- International Ergonomics Association

Domains of Specialization



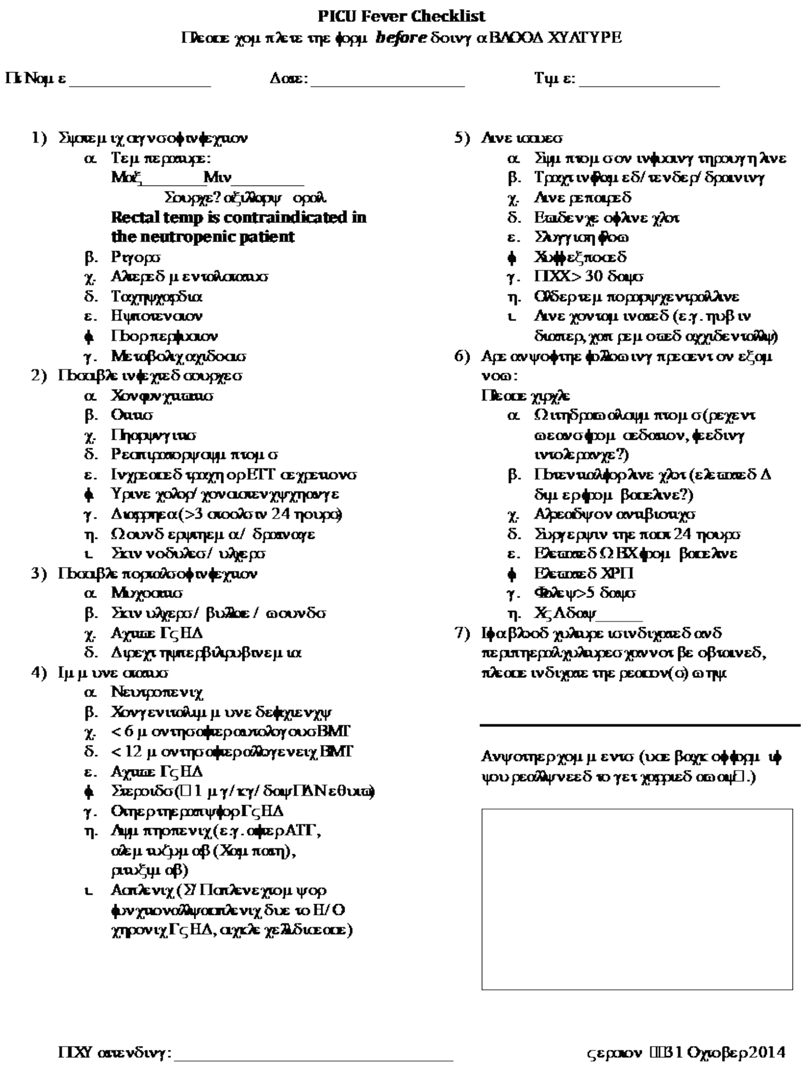
Clinical Decision Support for Blood Culture Use in Pediatric Sepsis Diagnosis

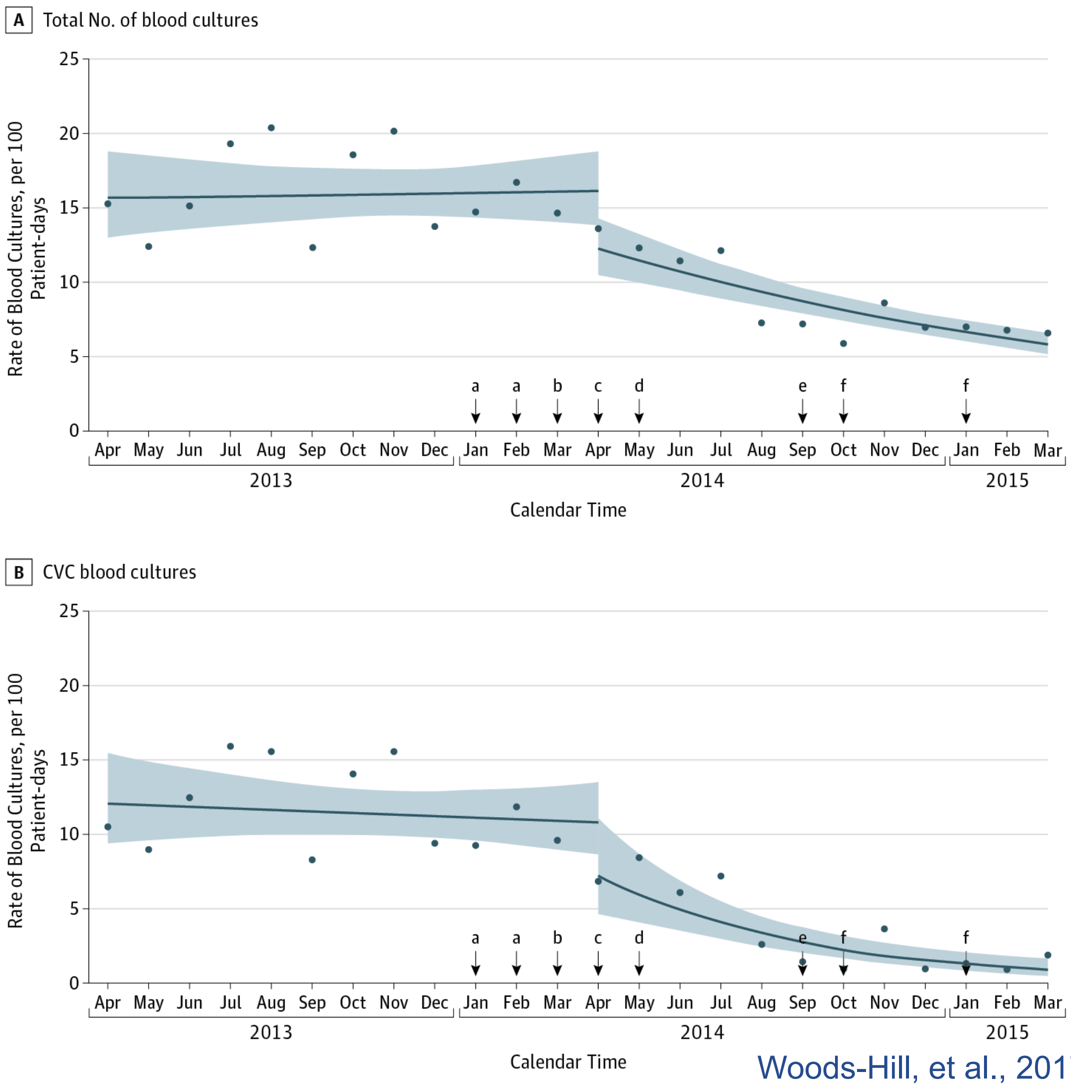
Funded by AHRQ (R21HS025238, R18 HS025642)

Background

- Blood culture - a key test for sepsis diagnosis
- Perceived as a low-risk test for a disease with disastrous outcomes
- Overuse of blood cultures resulting in
  - Additional tests
  - Unnecessary antibiotic use
  - Prolonged hospitalization
  - Increased healthcare costs

A Blood Culture Checklist





Woods-Hill, et al., 2017

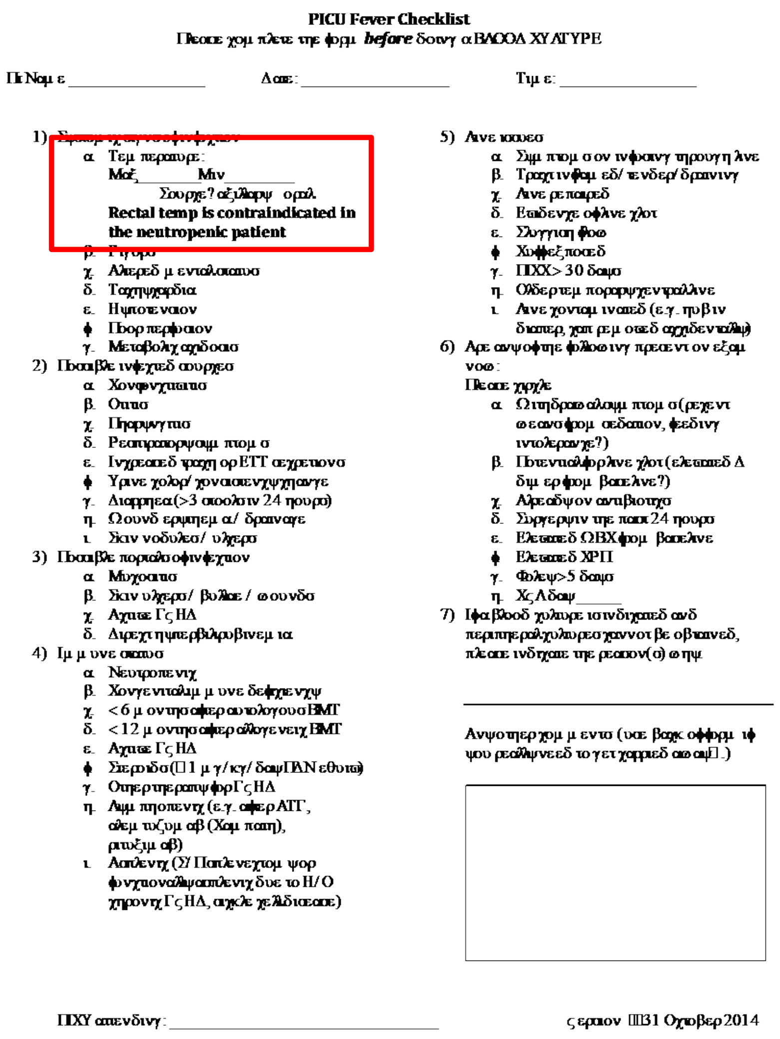
HFE Applications

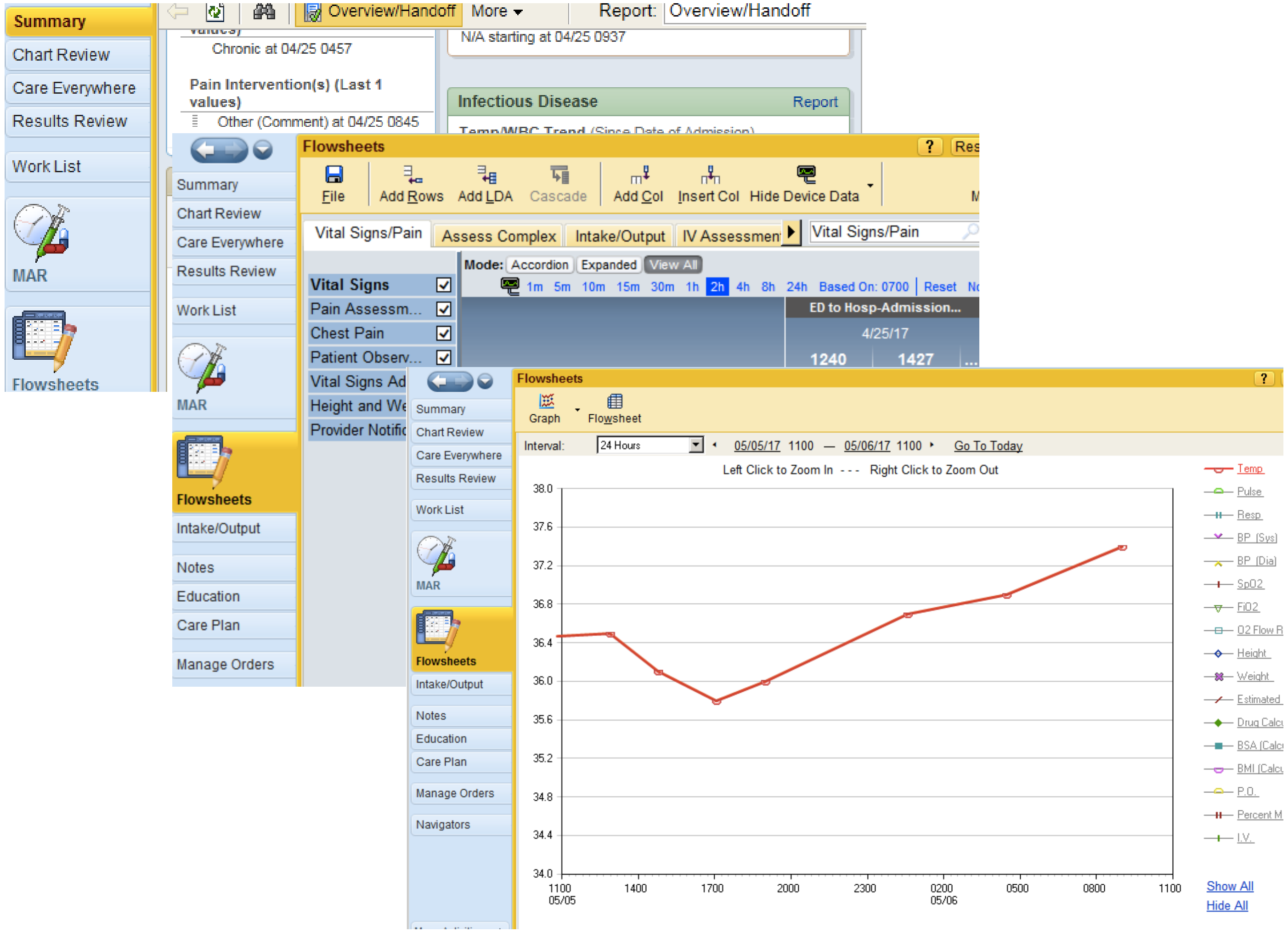
- Integration of the blood culture checklist into electronic health records (EHRs)
- Dissemination of the blood culture checklist

HFE Applications

- Integration of the blood culture checklist into electronic health records (EHRs)
- Dissemination of the blood culture checklist

Challenges to Using the Blood Culture Checklist





Critical Decision Method Interviews

- Weekly chart review to identify cases where a patient has
  - Fever and blood culture ordered
  - Fever but no blood culture ordered
  - No fever but blood culture ordered
- Interviewing clinicians involved in identified cases
  - 19 clinicians at Johns Hopkins Hospital (9 physicians, 4 nurse practitioners, 5 nurses, 1 nurse manager)
  - 37 cases (18 with fever and blood culture ordered, 2 with fever but no blood culture ordered, 17 with no fever but blood culture ordered)
  - Reviewing and discussing 1-3 cases during interviews

Critical Decision Method Interviews

PICU Pt. Timeline:

(For Interview re: BC Use and Sepsis Diagnosis)

Pt. Summary (at time of fever/hypothermia and/or BC):

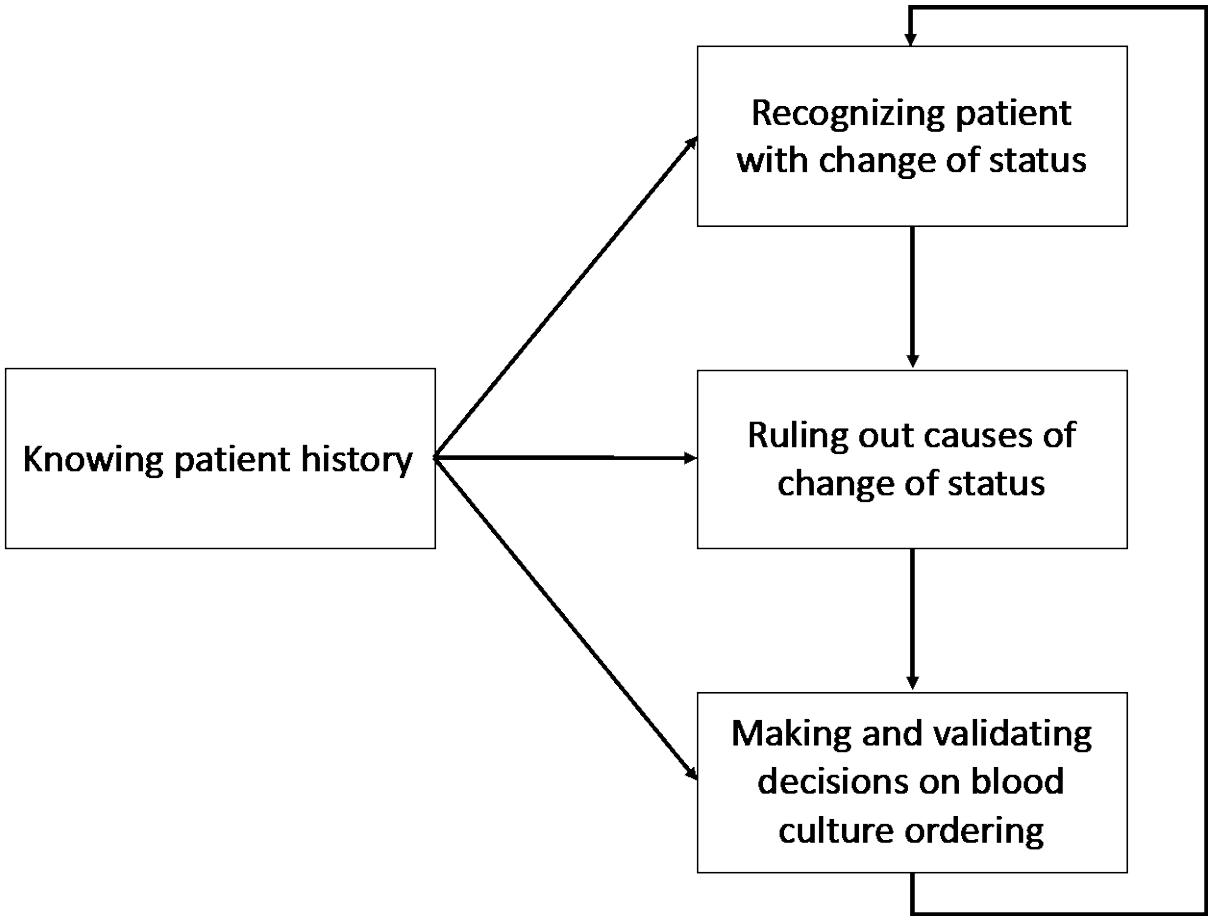
Pt. was admitted to 11S on **7.4.2017** from the ED and last transferred onto the PICU **9.1.2017.**
Pt. is a 24 y.o. female with HLH diagnosed 5/2017, treated with Etoposide and Decadron, Graves Disease s/p ablation and acquired hypothyroidism, RAD, Acne, Dry Eye Syndrome, mononucleosis who was admitted to the Oncology service on 8/23 for management of HLH flare and preparation for BMT. She now has multi organ dysfunction who remains on ECMO (**9/8**) support and CVVHD for renal failure.
Pt. has 3 arterial lines, and peripheral lines, implanted port, CVC double lumen, Hemodialysis access central line internal jugular dual lumen; non tunneled,

9.16.17 1050 BC (Arterial) Staphylococcus species, coagulase negative (Pt. was pan cultured due to hypotensive episode (and cefepime was escalated to meropenum, Pt. on vanc., acyclovir and ambisome)
9.17.17 0826 BC (Arterial) Staphylococcus species, coagulase negative
9.17.18-9.18.17 (overnight): Catherine had two episodes of hypotension and treated with albumin, epinephrine and calcium chloride
9.18.17 ECMO started to be weaned (Intermittently hypotensive with episodes of arrhythmias, had V-tach overnight)
9.18.17 1922 Central line BC **Staphylococcus species, coagulase negative**
9.21.17 0156 Pseudomonas aeruginosa

(Include (when applicable): date of admission, primary diagnosis, date/time of fever/hypothermia, date/time of BC, discharge date)

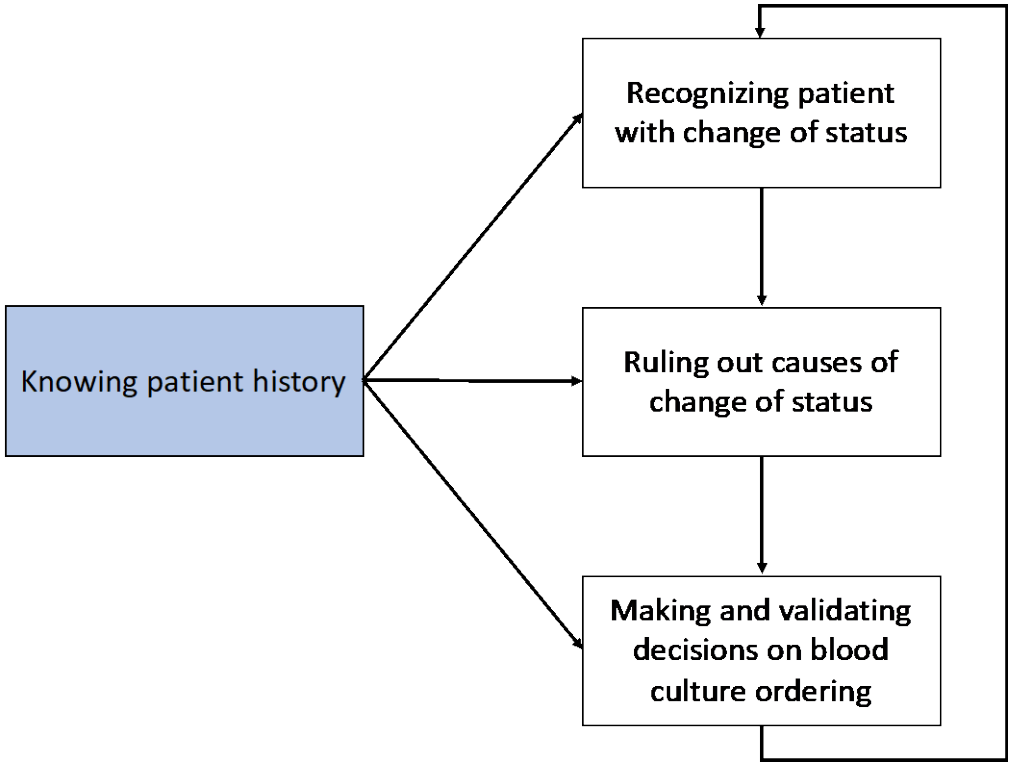
Critical Decision Method Interviews

- Results



Critical Decision Method Interviews

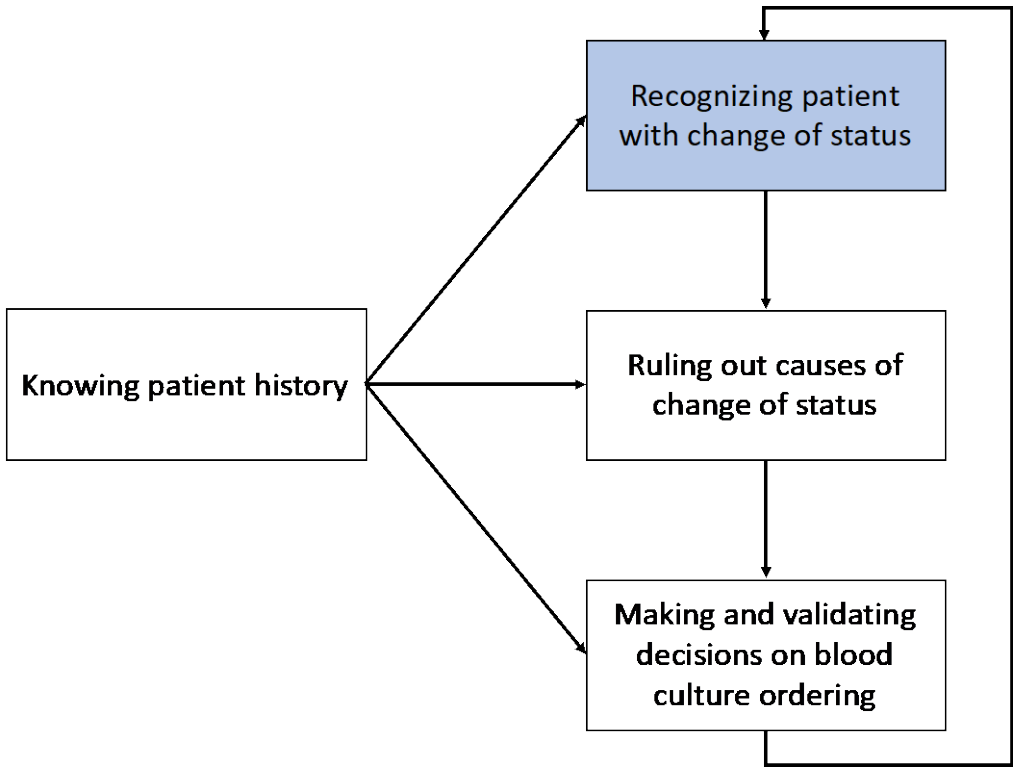
- Results



- Approaches
  - Long-term knowledge about a patient
  - Daily review of patient conditions
- Potential challenges
  - New providers or providers covering for others not having knowledge about a patient
  - Patient information scattered across different sources
- Implications
  - Summarizing patient information available in EHRs
  - Indicating other sources of patient information

Critical Decision Method Interviews

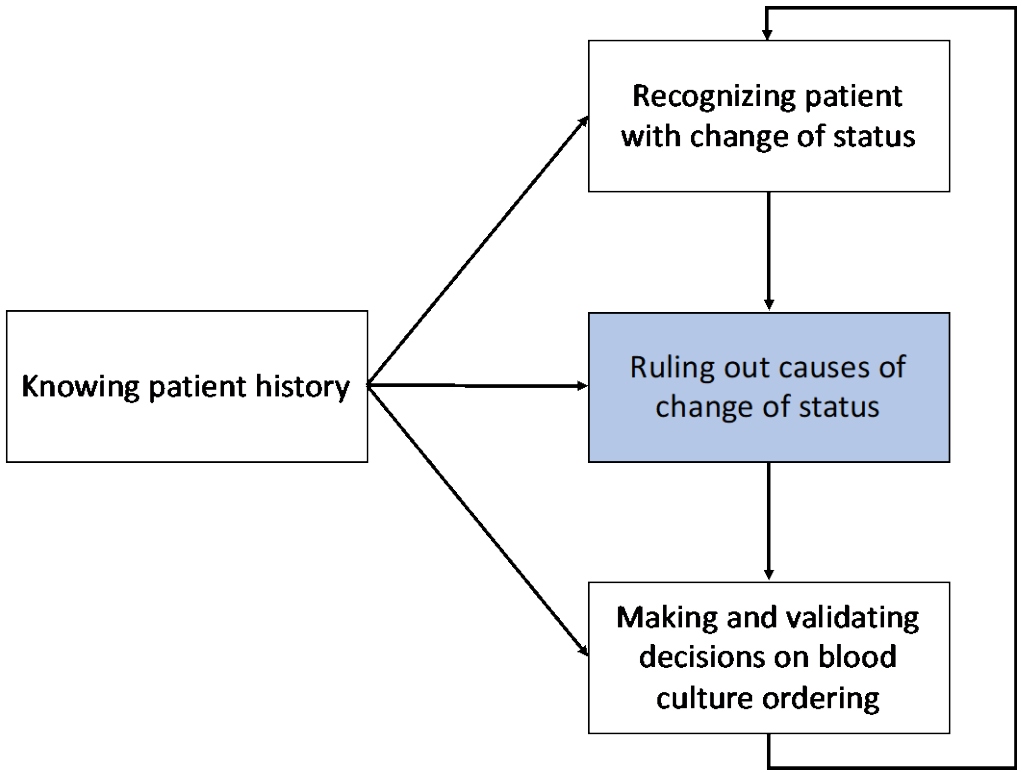
- Results



- Approaches
  - Monitoring change of clinical indicators (analytical)
  - Matching patient conditions with clinical patterns learned from past experience (intuitive)
- Potential challenges
  - Focusing only on current status
  - Different patients having different signs/thresholds
  - Focusing only on clinical indicators
  - EHR not bringing abnormal status to attention
- Implications
  - Providing information on current status and trend
  - Alerting clinicians about change of status
  - Learning and building a library of clinical patterns

Critical Decision Method Interviews

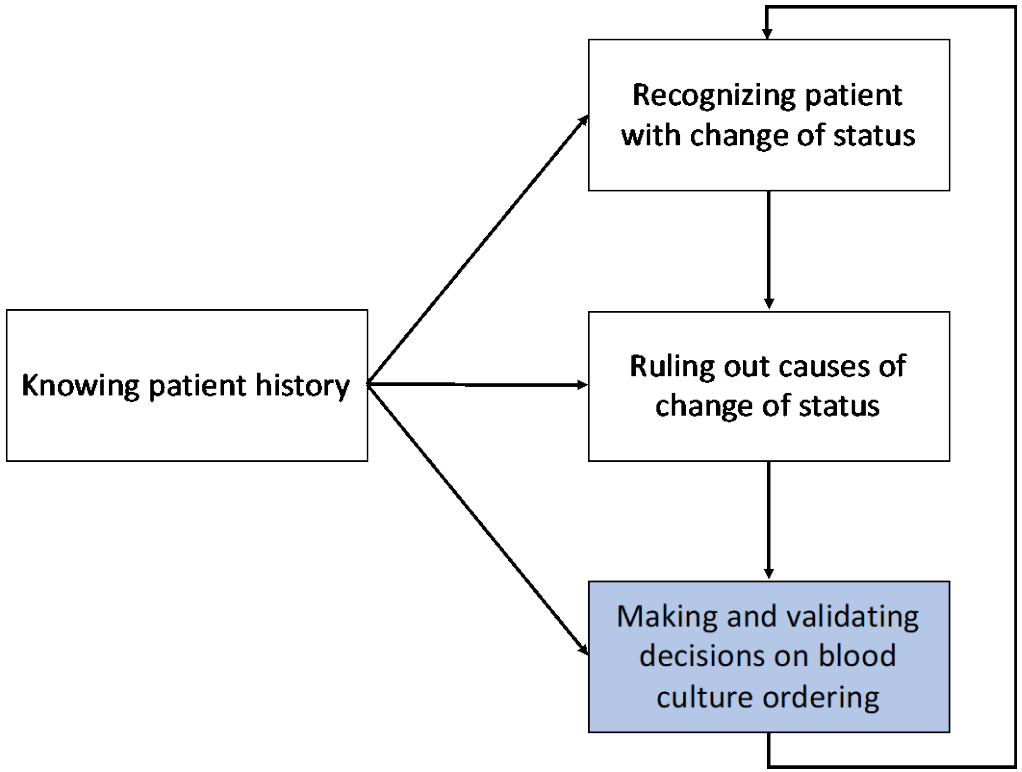
- Results



- Approaches
  - Considering potential causes of change of status
  - Understanding entire condition of patient
  - Matching patient condition with typical clinical representations of each cause (analytical vs intuitive)
- Potential challenges
  - Ordering blood cultures reflexively
  - Limited knowledge about potential causes and associated clinical representations
  - Limited time to collect patient information
  - Mismatch between patient condition and clinical representations because of incomplete information
- Implications
  - Indicating all potential causes
  - Indicating additional information needed and sources of the information

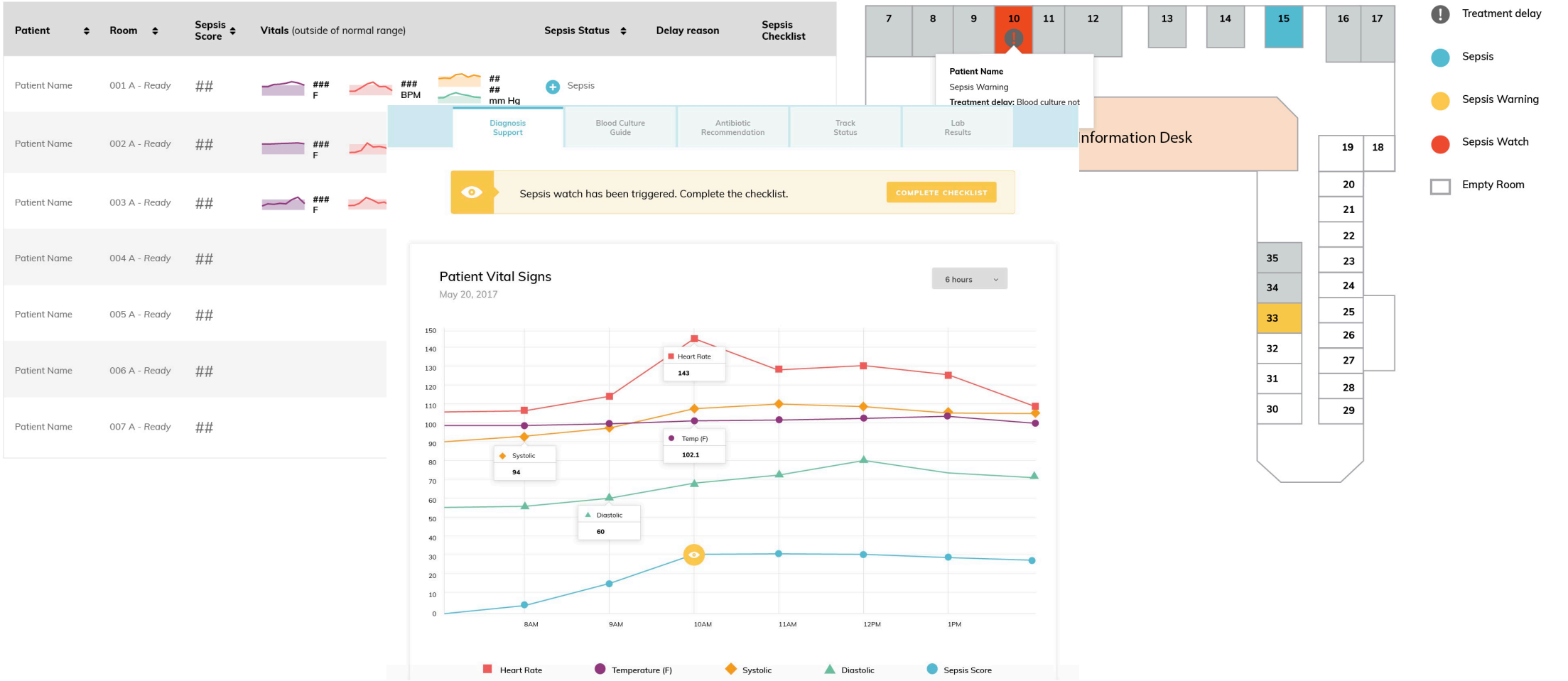
Critical Decision Method Interviews

- Results



- Approaches
  - Running decisions by senior physicians
  - Running decisions by nurse/nurse verifying BC orders
- Potential challenges
  - Junior physicians making decisions without the involvement of senior physicians
  - Senior physicians not challenging decisions made by junior physicians because of mutual respect
  - Junior physicians not challenging decisions made by senior physicians because of hierarchy
  - Nurses not challenging decisions made by physicians
- Implications
  - Forcing function to get approval from senior physicians
  - Balancing “hard stop” and “clinical need”

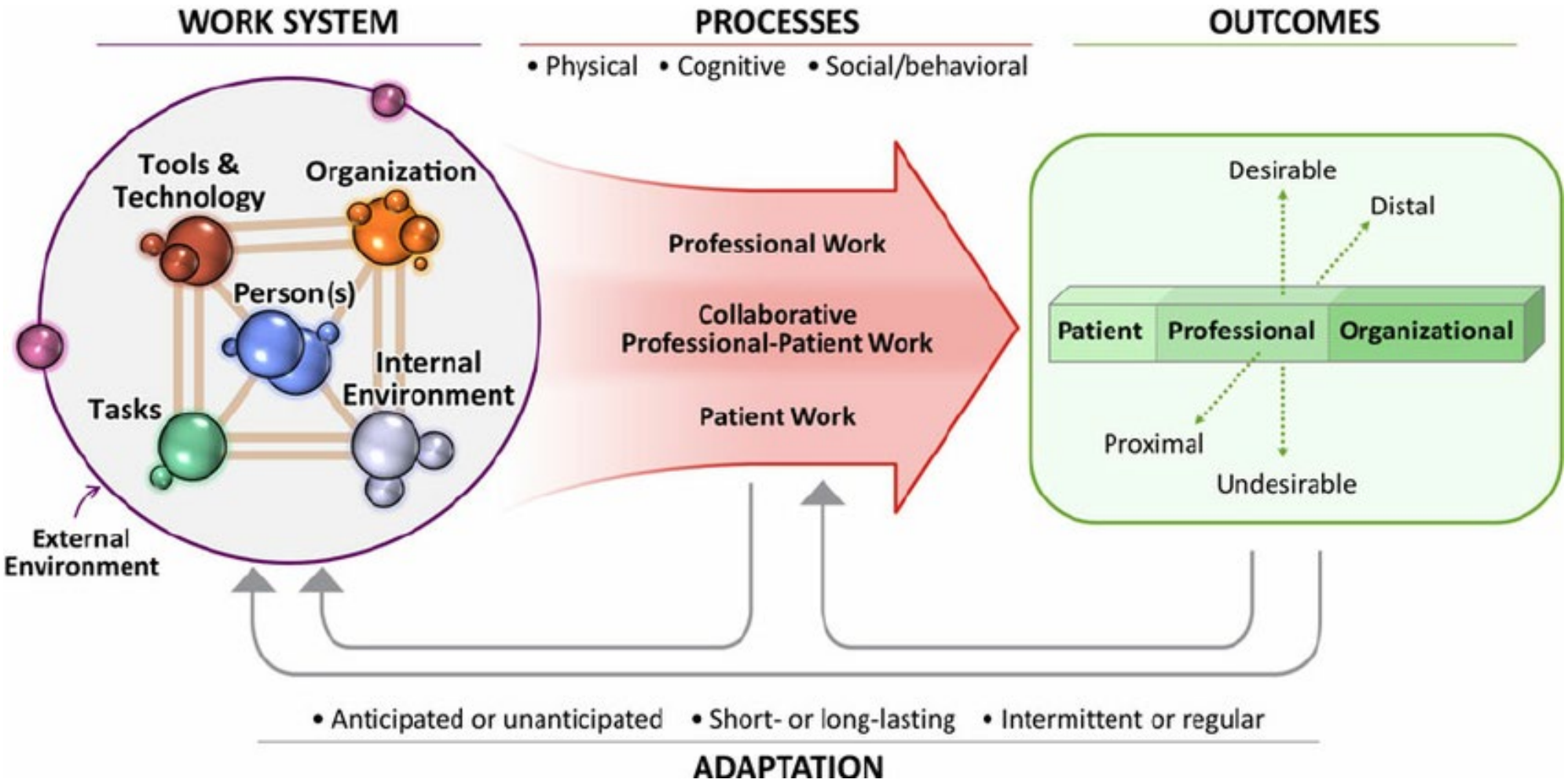
Prototypes


Patient
Room
Sepsis Score
Vitals (outside of normal range)
Sepsis Status
Delay reason
Sepsis Checklist
Patient Name
001 A - Ready
002 A - Ready
003 A - Ready
004 A - Ready
005 A - Ready
006 A - Ready
007 A - Ready
##
F
BPM
mm Hg
Sepsis
Diagnosis Support
Blood Culture Guide
Antibiotic Recommendation
Track Status
Lab Results
Sepsis watch has been triggered. Complete the checklist.
COMPLETE CHECKLIST
Patient Vital Signs
May 20, 2017
6 hours
Heart Rate
143
Temp (F)
102.1
Systolic
94
Diastolic
60
8AM
9AM
10AM
11AM
12PM
1PM
Heart Rate
Temperature (F)
Systolic
Diastolic
Sepsis Score
Patient Name
Sepsis Warning
Treatment delay: Blood culture not
nformation Desk
Treatment delay
Sepsis
Sepsis Warning
Sepsis Watch
Empty Room

HFE Applications

- Integration of the blood culture checklist into electronic health records (EHRs)
- Dissemination of the blood culture checklist

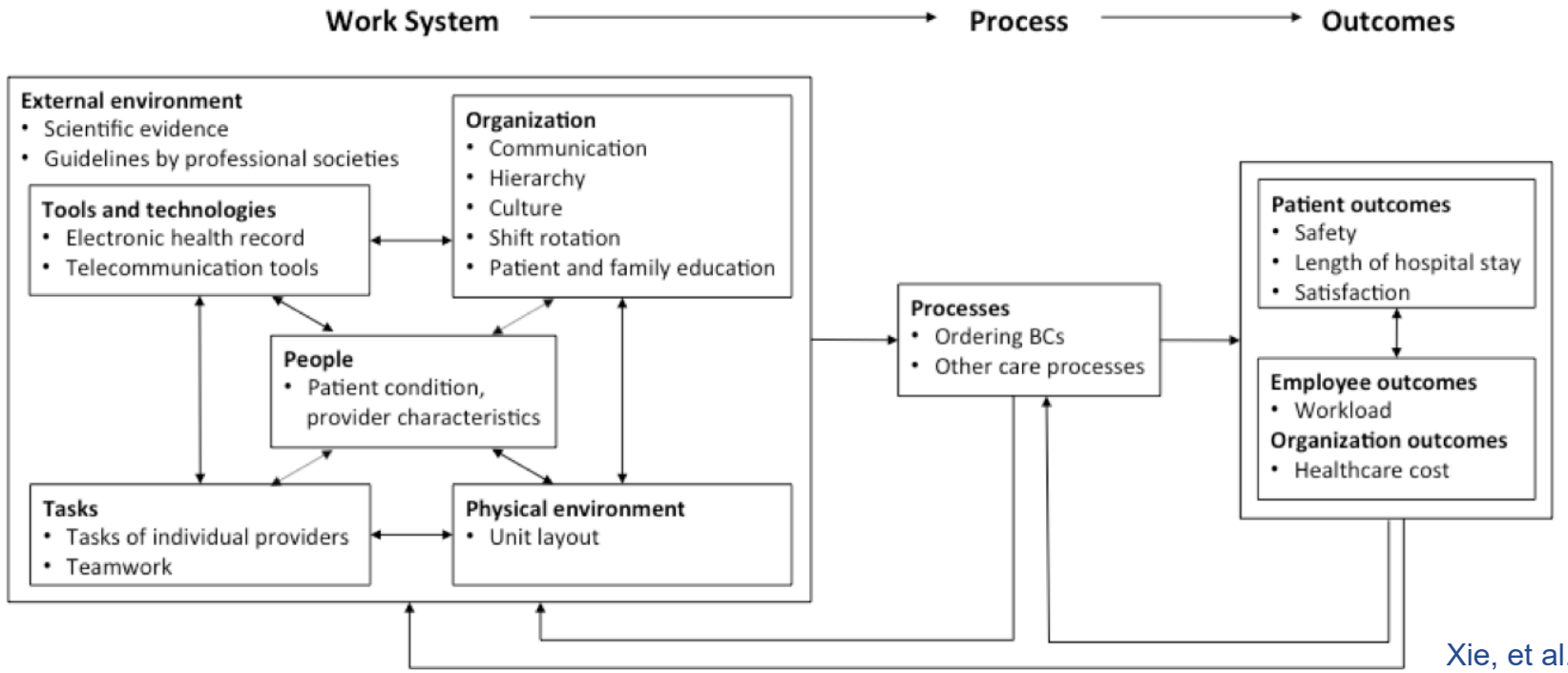
Systems Engineering Initiative for Patient Safety (SEIPS) Model



Holden, et al., 2013

Early Adoption by Two Hospitals

- Interview-based work system assessment
  - 2-day visit at each hospital
  - Face-to-face interviews with different stakeholders



Xie, et al., 2019

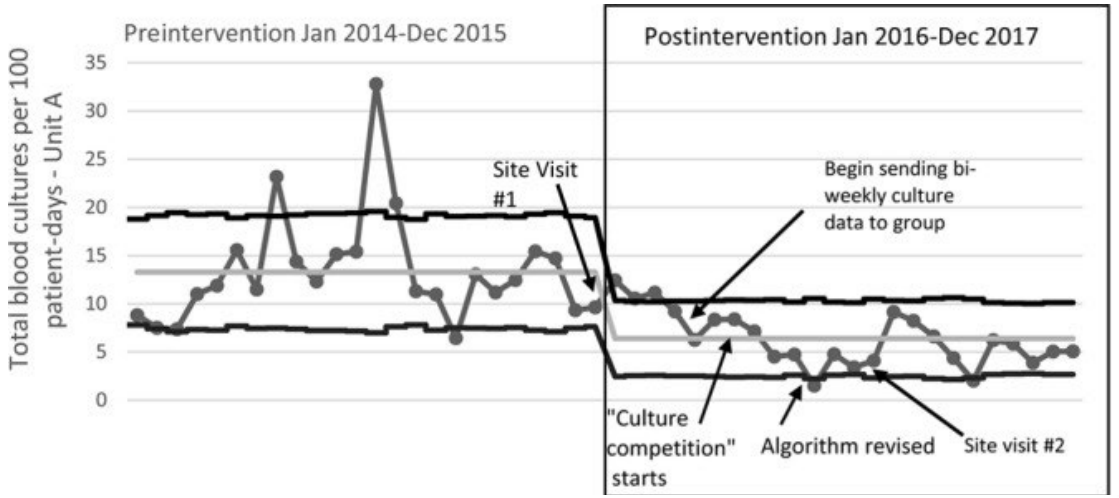
Early Adoption by Two Hospitals

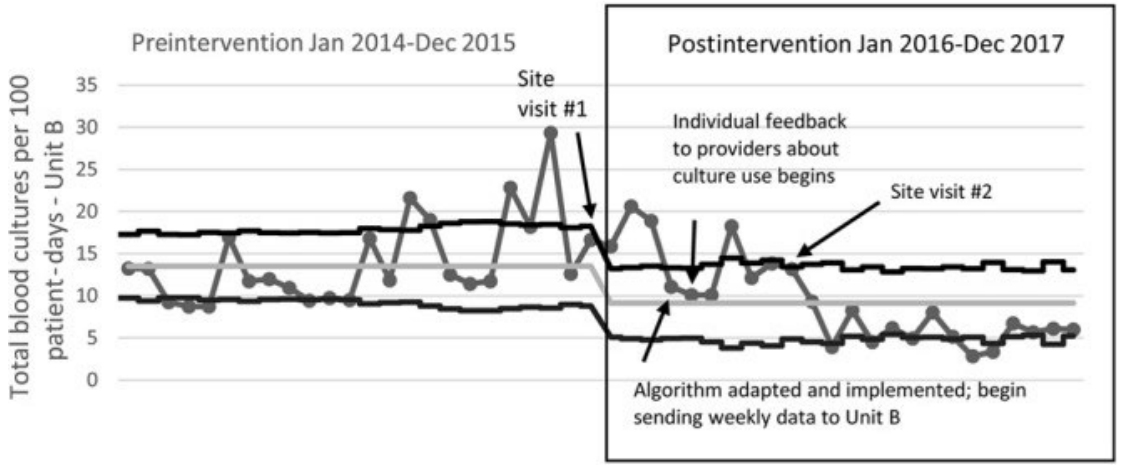
- Adaptation of the blood culture checklist to local teams and patient populations
- Customization of implementation strategies
  - Using the checklist to facilitate clinician communication
  - Educating clinicians about good blood culture ordering practices and the importance of teamwork to blood culture ordering decision making
  - Providing clinicians feedback on their blood culture ordering practices
  - Securing leadership support and identifying unit champions
  - Changing unit culture to alleviate barriers imposed by organizational hierarchy

Xie, et al., 2017

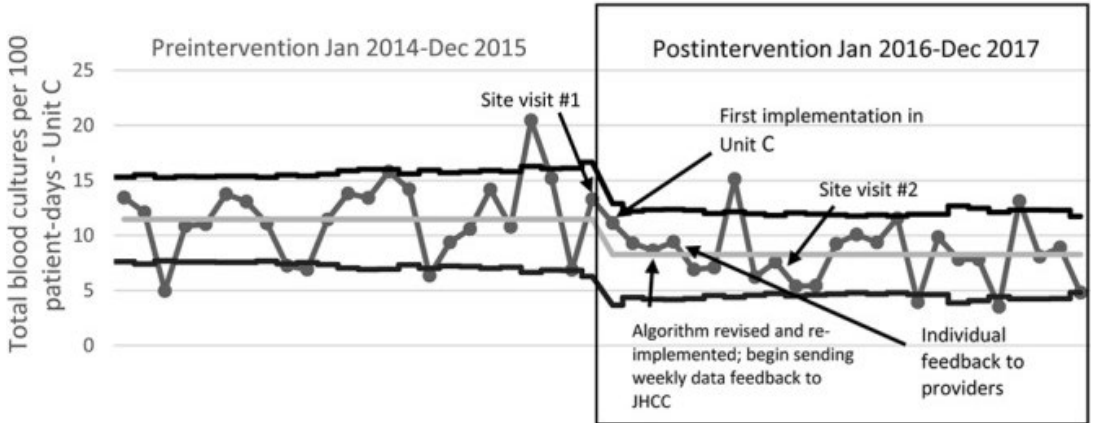
Early Adoption by Two Hospitals

Hospital A





Hospital B



Woods-Hill, et al., 2018

Large-Scale Dissemination

- A 15-hospital collaborative
- A participatory ergonomics approach
  - Identification of physician and nurse champions
  - Set-up of local quality improvement team
  - Adaptation of interview-based work system assessment to survey-based work system assessment
  - Monthly individual and group calls to facilitate the adaptation of the checklist and the redesign of local work systems and processes

References

- Holden RJ, Carayon P, Gurses AP, et al. SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients. Ergonomics **2013**; 56:1669–86.
- Woods-Hill CZ, Fackler J, Nelson McMillan K, et al. Association of a clinical practice guideline with blood culture use in critically ill children. *JAMA Pediatr*. 2017;171:157–164.
- Woods-Hill CZ, Lee L, Xie A, et al. Dissemination of a novel framework to improve blood culture use in pediatric critical care. *Pediatr Qual Saf*. 2018; 3:e112.
- Xie A, Woods-Hill CZ, King AF, et al. Work system assessment to facilitate the dissemination of a quality improvement program for optimizing blood culture use: a case study using a human factors engineering approach. *J Pediatric Infect Dis Soc.* 2019; 8:39-45.

Contact Information

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AGENCY FOR HEALTHCARE RESEARCH AND QUALITY

Composable Approach in Health IT and Cognitive Support for Clinicians

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Objectives

- Describe the composable approach
- Discuss issues related to cognitive support
- Present snapshot of research results (many years)
- Higher-level system advantages of composable architecture
- Future directions
- Discussion

Historical - What Happens When Ordinary People Have Control, Can Create?

- Usability is still problematic in many systems
- Cognitive aspects

- **History: GUI, browser, word processing**
- **Medical: users' specialized expertise not reflected in systems**

What if?

Users could create and share their own data elements, UI?….

- Intelligent use of space
- Human creations in flexible systems beget additional creativity

Commercial EHRs Are Predominantly Menu-Driven

Previous Patient | Next | Refresh | Order | find patient | Find Visit | Health Issues | Enter Dcoument | Clinical Path | Allergies | Signature | Worklist | Task View | Flowsheet manager | Prescription writer | Print | Add provider | change location | more info | end visit | Discharge | Help

JONES, JANET MRN 555666777-098 99884455-9988 4455 65Y (15-7-57) Male
Allergies: Intolerances: Comment Pager
Wt: 88kg ht: 190cm ABW: kg CrCl: mL/min SCr: 0.9- (25 Oct) Adm Date: 9/30/19 BSA: sqm BMI: 40 kg/m2 Status: ADM

Options
Chart selection
This All available

Date ranges:
Date: __ordered __resulted
From:

To:

__Keep configuration

Format
By department

Check:

Filters:

Status/priority
None

Order selections:
None

Department:
None

Dispense type:
None

Complete Verified
All All

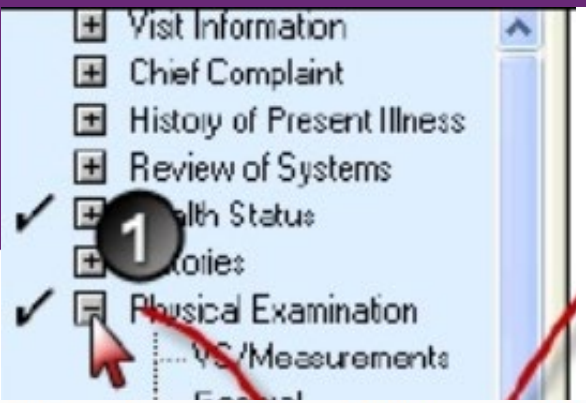
Styles:

Group by:

Format	Group	Add note	Specimen	Copy/ reorder	Stop	Reorder	Modify	Reinstate	Release Hold	Manage Orders	Sign	Suspend	Reactivate	Other Actions	Pharmacy	Med Request		

Orders	Order No.	Order date	Status	Date	Entry Date
Laboratory					

+Imaging
+Notes
+Encounters
-Study Reports
-Xray – Thoracic – 07-22-20
-Xray – Foot (left) – 07-21-20
-Ultrasound of abdomen – 06-21-20



Sept. 16, 2014

AMA Calls for Design Overhaul of Electronic Health Records to Improve Usability

For immediate release:

Sept. 16, 2014

Doctor, Heal Thyself: Physician Burnout In The Wake Of Covid-19

Lipi Roy, MD, MPH Contributor

Healthcare

I write about medicine, addiction, social justice...& some COVID-19.

Physician burnout and suicide were epidemics before the current pandemic. GETTY

"Nationwide, our doctors are jumping from rooftops, overdosing in call rooms and hanging themselves in hospital chapels. It's

Nurses protest EHR patient safety risks, healthcare reform woes

Author **Jennifer Bresnick** | Date May 27, 2014

National Nurses United (NNU) **has launched** a campaign to protest the patient safety risks inherent in EHR use and the detrimental impact of accountable care reforms on how patients receive inpatient care. Representing a number of state and local nursing organizations, NNU decries the "unchecked proliferation" of EHR technology and the "severe risk of harm" brought about by attempts to significantly reduce hospital admissions and shift care to primary care providers and outpatient settings.

TIMES COLONIST

NEWS | CANADA 150 | OPINION | BUSINESS | SPORTS | ENTERTAINMENT | LIFE | DRIVING | FLYE

Nanaimo doctors say electronic health record system unsafe, should be shut down

CINDY E. HARNETT / TIMES COLONIST
MAY 27, 2016 06:00 AM

Philosophy

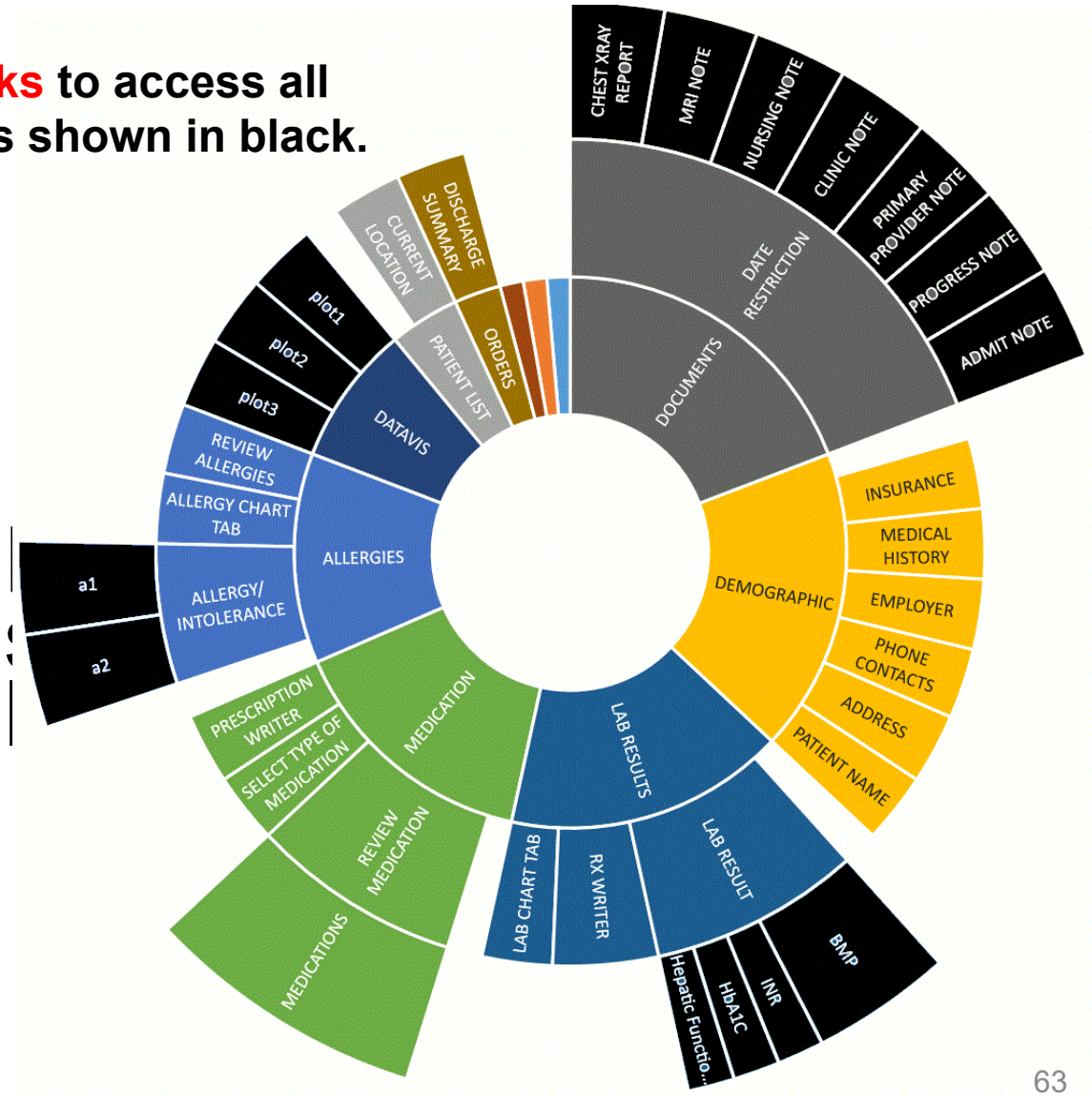
- **Any element is available to be composed, shared**
  - Analogy: whole genome, some genes are turned on
- **Standardization v. customization – not an issue**
- Customization **in a system made to be customized** is different than 'EMR optimization'
  - The code doesn't change., so not a problem.
- **Customization must be easy**– so click/drag, object manipulation
  - Such programming can also be fewer lines, less error prone
- **Assumption in computing – that we can model the process in advance;**
  - **Not always true in healthcare.**
- 3rd party visualization
- Control shifted to policy

Senathirajah Y, Bakken S. Architectural and Usability Considerations in the Development of a Web 2.0-based EHR. Stud Health Technol Inform, 2009;143:315-321. doi: 10.3233/978-1-58603-979-0-315. PMID:19380954.
Senathirajah Y, Bakken S. Important Ingredients for Health Adaptive Information Systems. In: User Centred Networked Health Care, A. Moen et al., Eds, 2011 EFMU, IOS Press, 2011. Stud Health Technol Inform. 2011;169:280-4.

Display Fragmentation in a Commercial Inpatient System - Clinical Elements Only

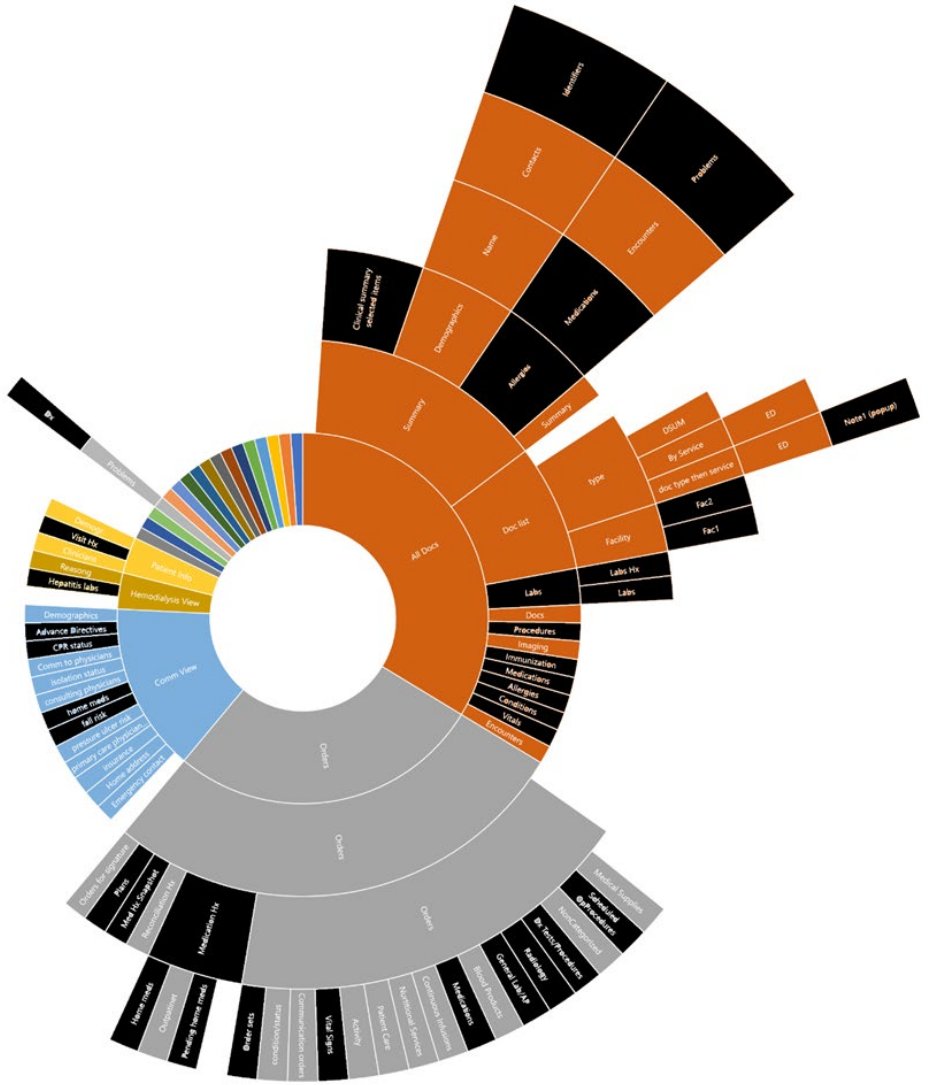
Documents	Date restr	Chest Xray report	
		MRI note	
		Nursing note	
		Clinic note	
		Primary provider note	
		Progress note	
		Admit note	
Demographic	Insurance		
	Medical History		
	Employer		
	Phone contacts		
	Address		
	Patient name		
Lab results	Lab result	BMP	
		INR	
		HbA1c	
		Hepatic Function panel	
	Rx writer		
	Lab chart		
Medication	Review Medication	Medications	
	Select type of medication		
	Prescription writer		
Allergies	Allergy/intolerance	a1	
		a2	
	Allergy Chart tab		
	Review allergies		
Data visualization	plot1		
	plot2		
	plot3		

Total 37 clicks to access all the elements shown in black.



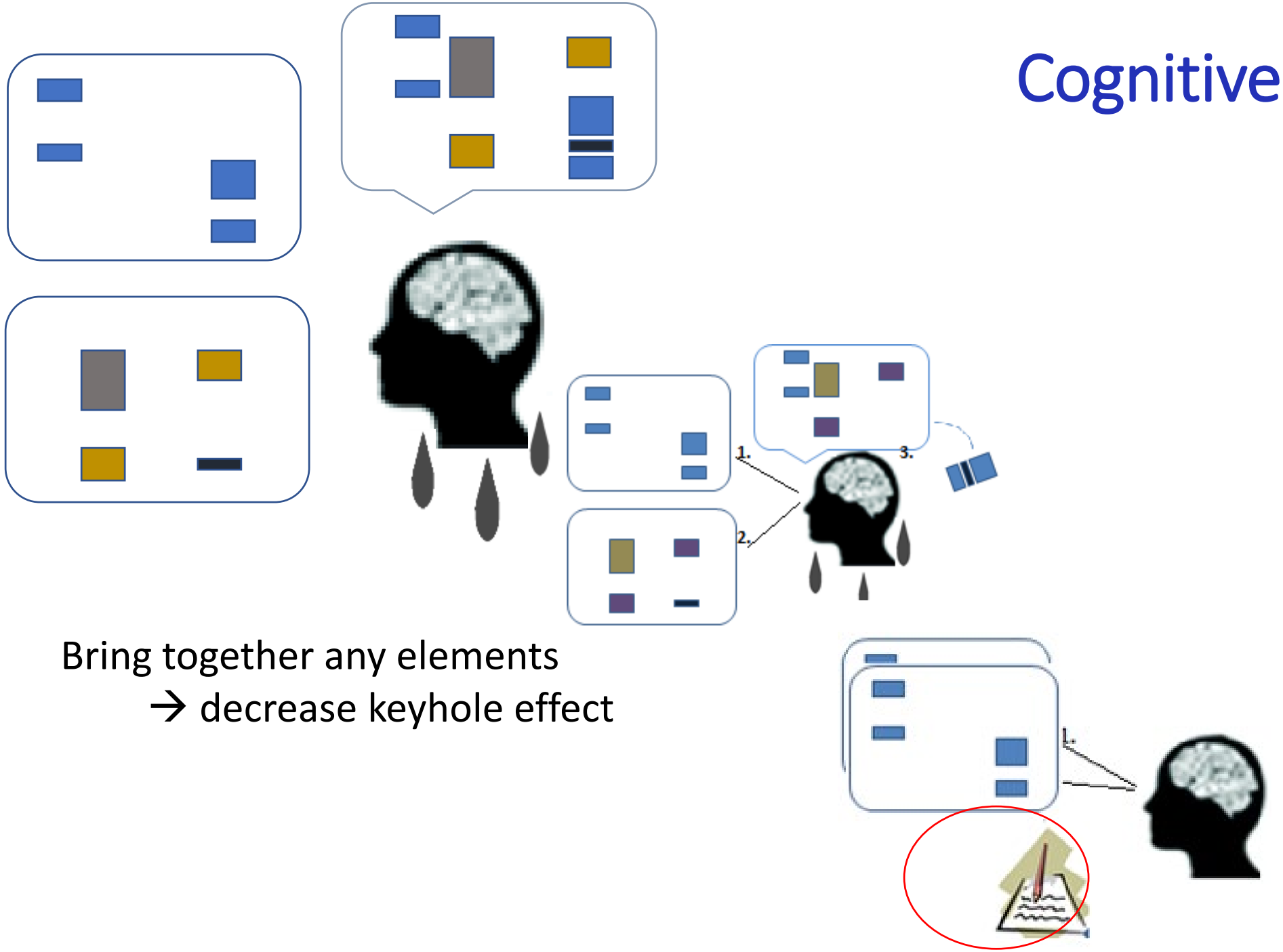
Display Fragmentation

- Perception, attention, memory, are cognitive resources
- Screen transition requires hand-eye coordination → cognitive load → interruptive to clinical reasoning →



Senathirajah Y, Kaufman DR, Cato KD, Borycki EM, Fawcett JA, Kushniruk AW. Characterizing and Visualizing Display and Task Fragmentation in the Electronic Health Record: Mixed Methods Design. JMIR Hum Factors 2020,7(4) e18484

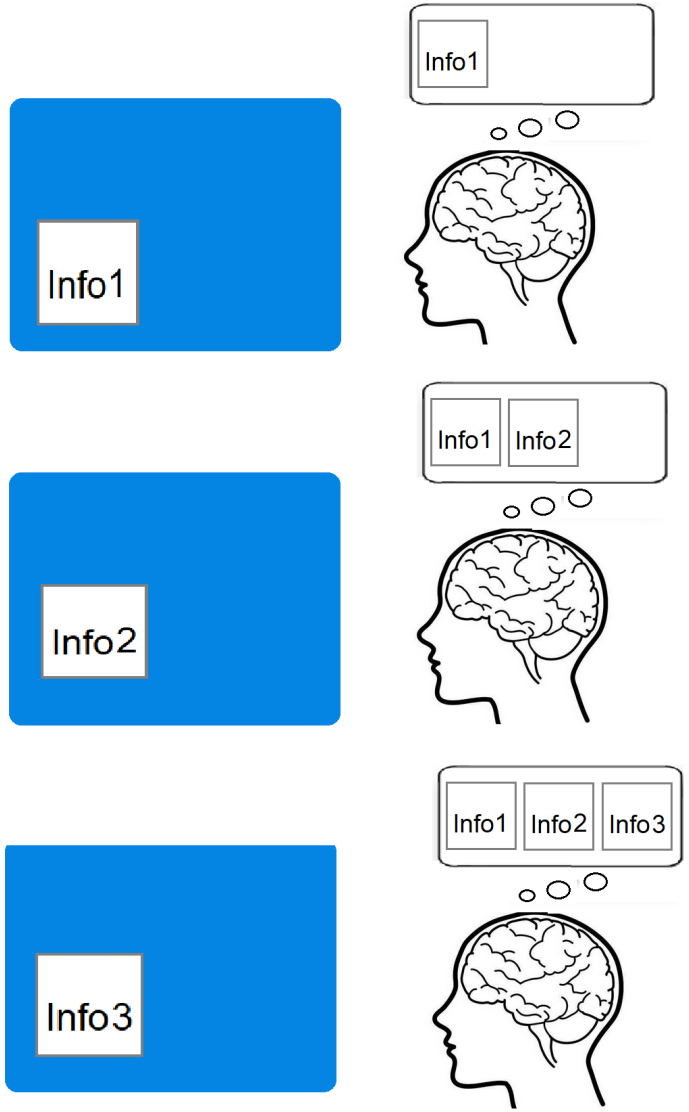
Cognitive load

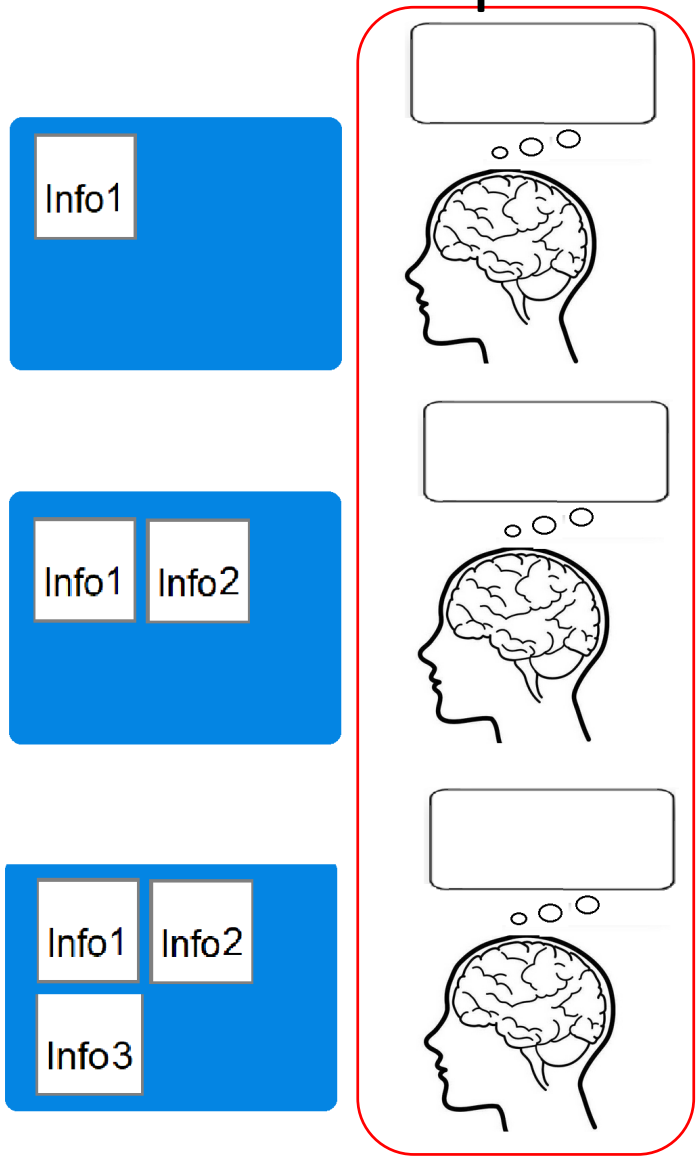


Bring together any elements

→ decrease keyhole effect

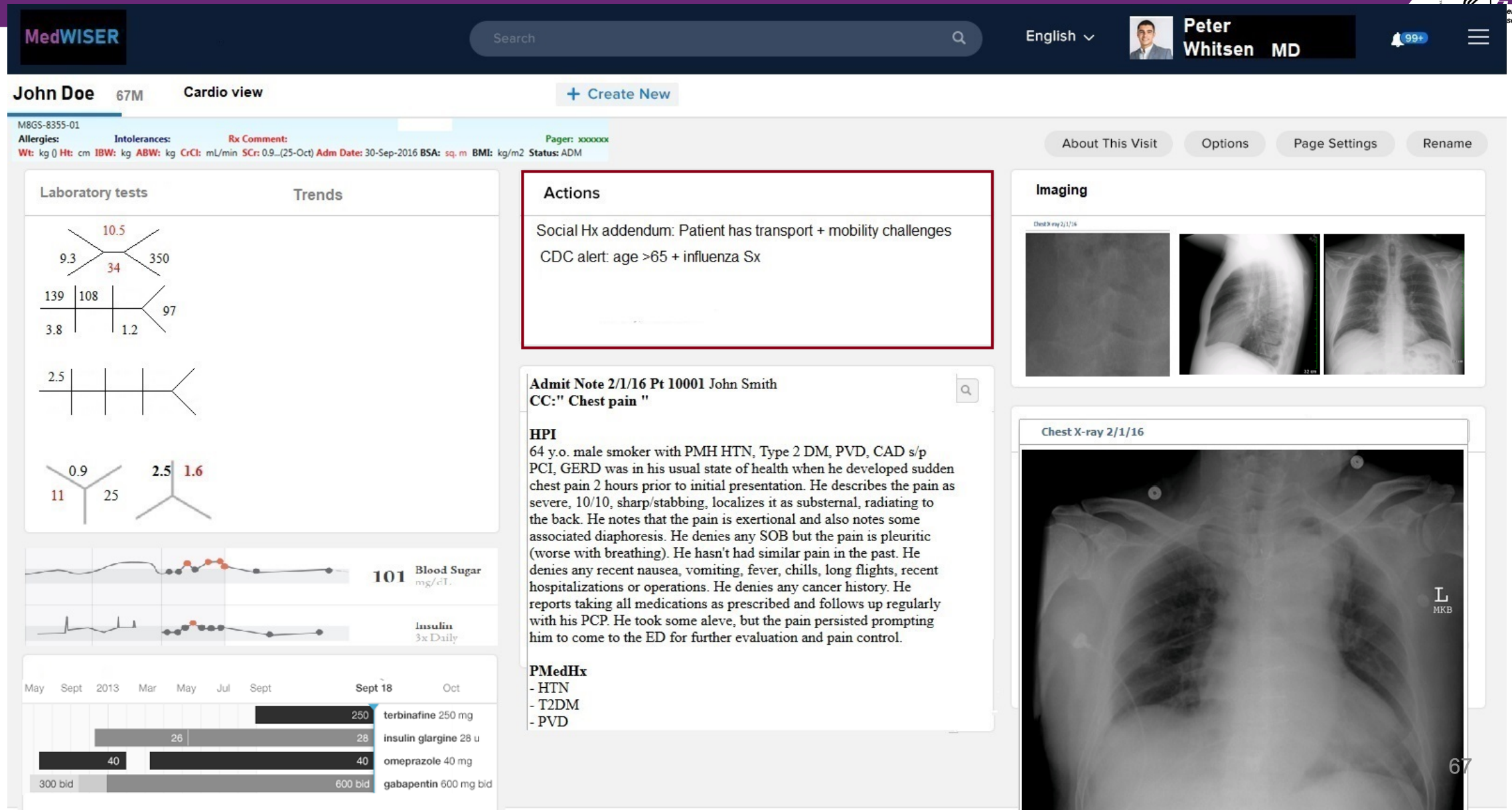
Cognitive load: conventional v. composable





Senathirajah Y, Kaufman D, Bakken S. (2014) The Clinician in the Driver's Seat: Part 1 - A User-composable Electronic Health Record Platform. J Biomed Inform 52(Dec):165-176. Epub: Oct 2014

In the Illustration Below, the User Has Assembled a Display With Seven Information Elements from Different Parts of the EMR



Covid Guidance | Summary

+ Add Widget | Options | Rename | Remove Page | Share Page

Vitals

Covid screening summary

Covid19 Screening Symptom summary

Confusion
Chronic health conditions - difficulty managing because of difficulty breathing
Care or close contact with a confirmed COVID-19 patient

Covid app output

- age>60
- Male - higher risk
- Diabetes
- Hypertension
- Obesity
- Lisinopril
- RSV Negative
- Lymphopenia

Current Medications

Lisinopril
MetFORMIN Glucophage 500 mg oral extended-release
VENTOLIN HFA 90 mcg/actuation inhl inhaler
MULTIVIT-MINERAL/ORAL

Diagnoses

Diabetes
Hypertension
Obesity
Non-alcoholic fatty liver disease (NAFLD)

BMP

Coagulation tracking

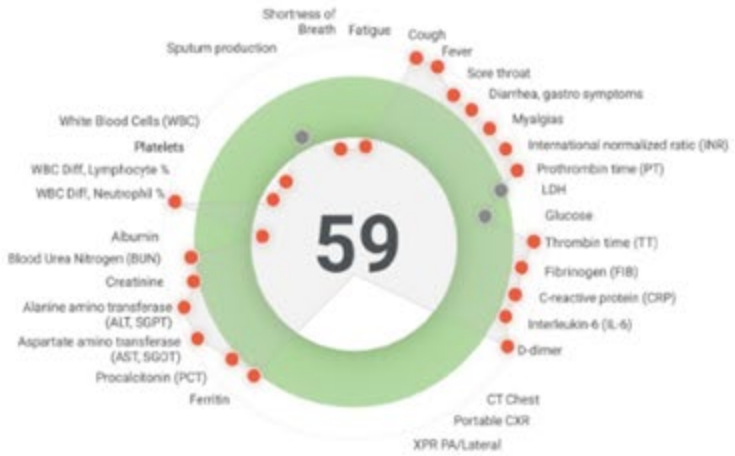
Lab Name	Short Name	Value	Range	Units
Partial thromboplastin time	activated	46.0	0-25	plasma
Prothrombin time	PT	11.0	10.7 - 15.0	seconds
Platelets	Platelets	140.0	150-440	10^9/L
D-dimer	D-dimer	220.0	0-250	ng/mL

CBC

Lab Name	Short Name	Value	Range	Units
Hematocrit	HCT	42.0	37 - 51	g/dl
Hemoglobin	HGB	13.4	13 - 18	g/dl
Platelet Count	PLT	300.0	140 - 440	103/cumm
Red cell distribution width	RDW	12.0	11.6-14.6	%
White Blood Count	WBC	11.4	3.6 - 11.2	103/cumm
sodium	Na	3.9	0.8-1.2	mg
	Na	3.9	0.8-1.2	mg
Erythrocytes	RBC	6.0	4.60-6.20	10^12/L
MCHC	MCHC	90.0	32-36	g/dL
MCH	MCH	33.0	28-32	pg
Platelets	Platelets	140.0	150-440	10^9/L
WBC	WBC	3.0	0-5	mm^3
Neutrophils/100 WBC	Neutrophils/100 WBC	45.0	3-4	%
Lymphocytes/100 WBC	Lymphocytes/100 WBC	20.0	60-75	%

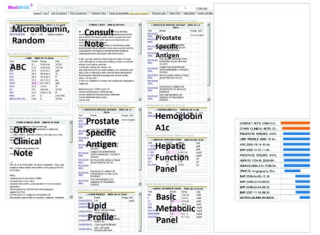
Progress note 6/1/12

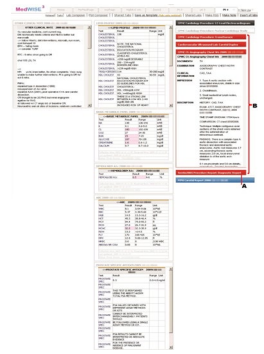
Covid lab summary



Chest X-ray upright 2/1/16

Early Findings





- 3 strategies of design/interaction
- Juxtaposition as cognitive support
  - Ordering, reminders, regions, color coding, intelligent uses of space
- 77% decrease in repetitious navigation, up to 6X time savings
- Teams caring for the same patients will jointly standardize display
- Similar diagnostic accuracy
- Checklist effect

Senathirajah Y, Kaufman D, Bakken S. (2014) Clinician in the Driver's Seat: Part 2 - Intelligent Uses of Space in a Drag/drop User-composable Electronic Health Record. J Biomed Inform 52(Dec):177-188. Epub: Oct 2014

Senathirajah Y, Kaufman D, Bakken S. User-composable Electronic Health Record Improves Efficiency of Clinician Data Gathering for Patient Case Appraisal: A Mixed-Methods Study. eGEMs (Generating Evidence & Methods to Improve Patient Outcomes). 2016;4(1):7.

Comments

"…very much appreciate the fact that I can look at an x-ray like within all my other stuff…frustration with [vendor system] is that I'm going back and forth, back and forth all the time, and then visually I can't see graphically the trends and everything, everything's going to be text based , I'll be in the middle of a note and I can't gather data for somewhere else, and it's very frustrating."

"as I'm working a patient and I'm working them up, and I'm writing a note, say I'm writing a note here (motions to right-hand col) and I'm drawing labs, **everything is on one page**."

- "it's quicker, I don't have to click as much, and dig through as much as on …,"

"widgets which are based on apps for so it's kind of so intuitive…"

EHR Risks (Partial)

Conventional

- Omission by user in search > error
- Cognitive load due to need to retain items in Working Memory
- User viewing patterns hard to view
- Possibly lack of fit to task, specialty, case, role
- No checklist
- Hard to change > potential errors last

Composable

- Omission by user > error?
- Shared omission > Dx momentum error?
- Cognitive load due to UI change?

Senathirajah Y. (2015). Safer design - Composable EHRs and Mechanisms for Safety. Borycki EM, et al., eds., IOS Press. Stud Health Technol Inform 2015:218:40602. PMID:26262532

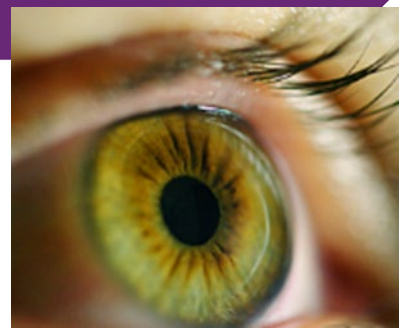
Senathirajah Y, Kaufman D, Bakken S. Essential Questions: Accuracy, Errors, and User Perceptions in a Modular, User-composable Electronic Health Record. In: Context-Sensitive Health Informatics: Human and Sociotechnical Approaches. IOS Press. Stud Health Technol Inform 2013:194:181-187.

Composable Systems - Usability and Safety Studies

- Eye tracking – what UX design aspects are cognitively loading?
  - (orders, results, documents., flowsheets, patient list, summary)
- Effects of user UI sharing – omissions, errors, transfers?
- Crossover studies – comparison of conventional v. composable EHR UI
- ED simulation - interruptions in high-stress scenarios, multiple patients and EHR record switching

Senathirajah Y. (2015). Safer design - Composable EHRs and Mechanisms for Safety. Borycki EM, et al., eds., IOS Press. Stud Health Technol Inform 2015:218:40602. PMID:26262532

What Features Are Most Cognitively Loading in EHRs? Solutions?



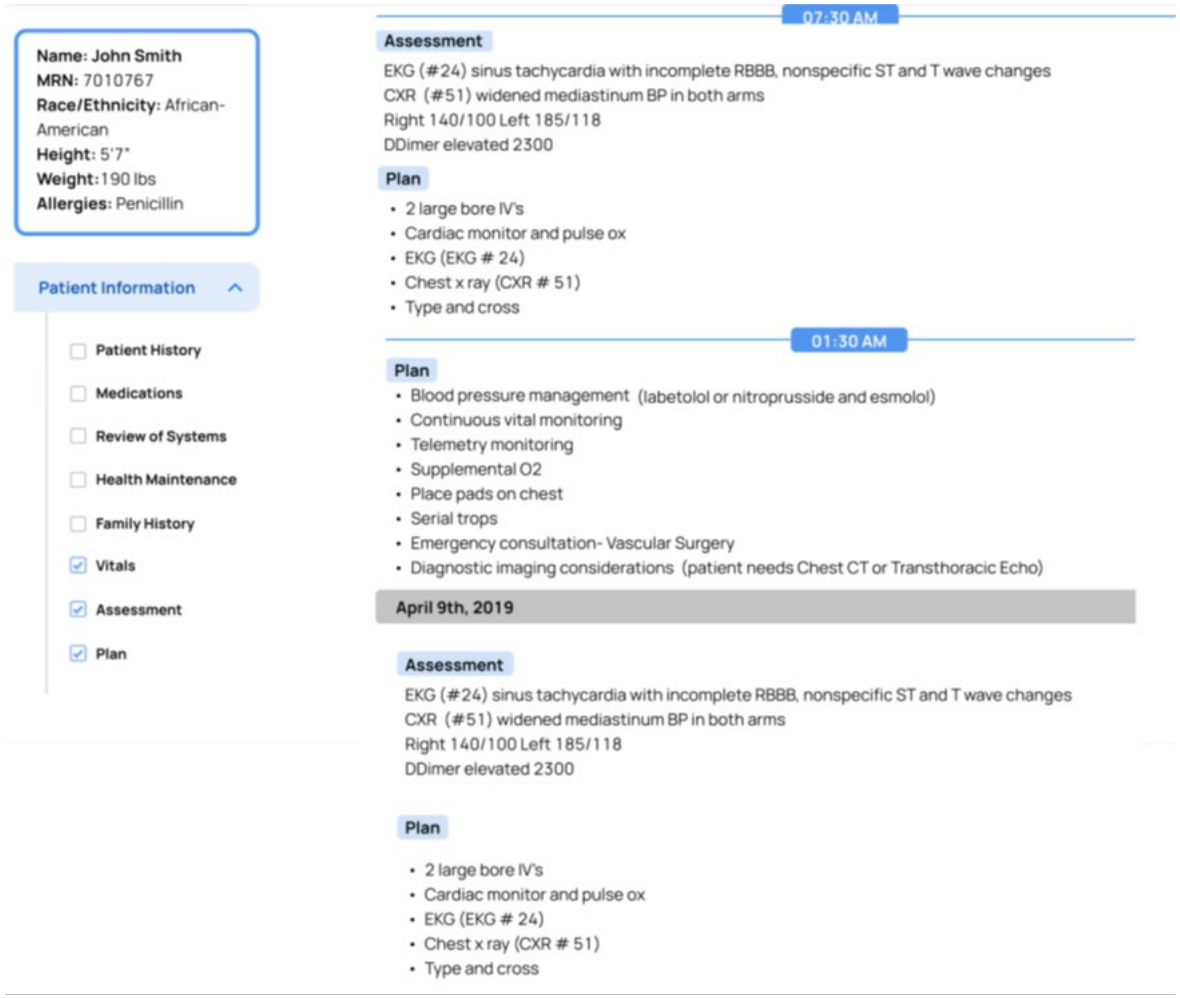
- Interview/observation/eye tracking neuro nurses, ICU/ED docs (n=9) doing 6 tasks
- UX issues:
  - Long document lists – double click–
    - too long- omission of info
  - Flowsheet filling
  - Orders
- As per user:
  - pain assessment documentation, admissions

Pupils dilate with increased mental effort
Software subtracts effects of lighting - a more objective measure of cognitive load?

Krejtz et al. Eye tracking cognitive load using pupil diameter and microsaccades with fixed gaze. PLOS One, 2018. https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0203629

Design Patterns

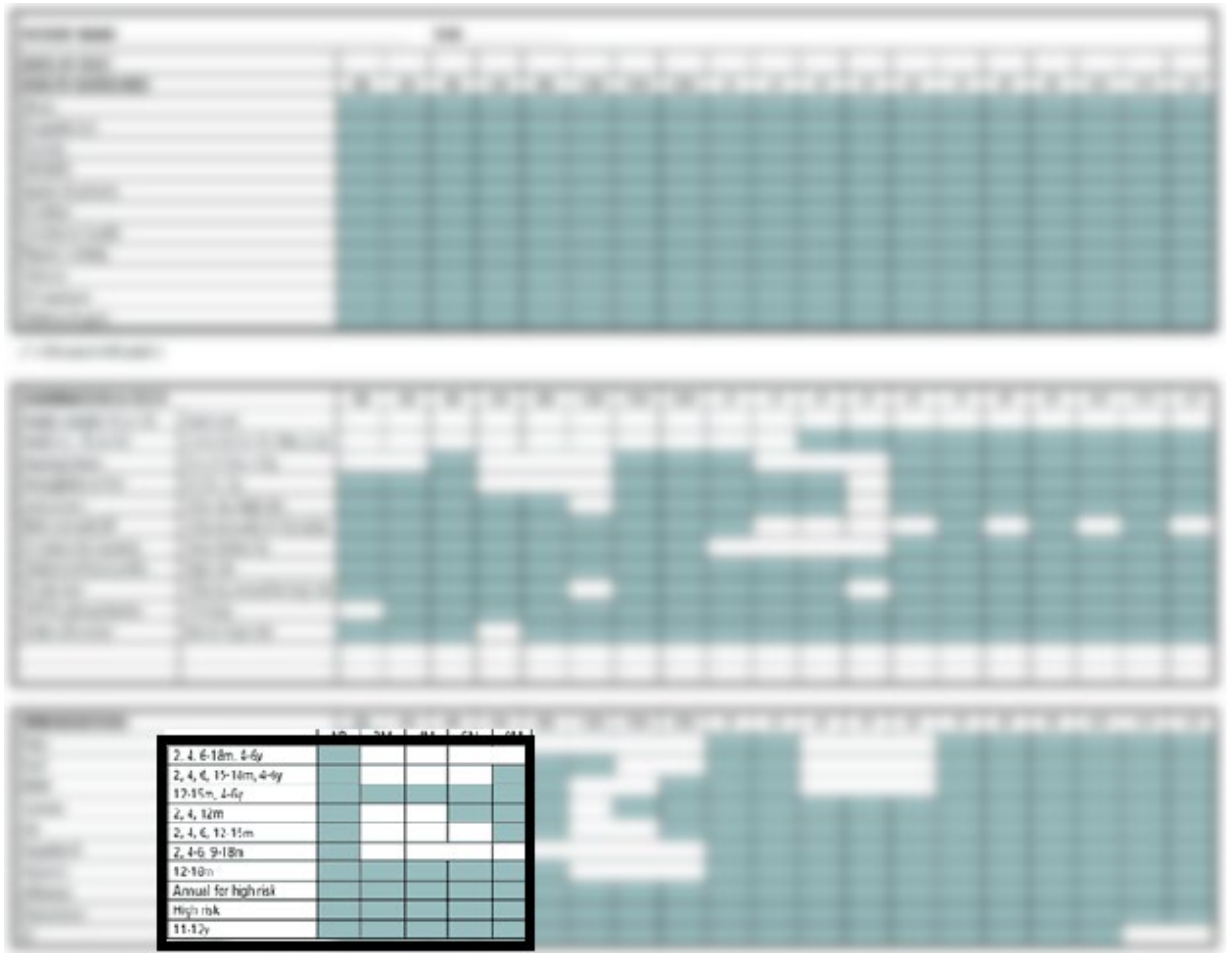
Note 1 link
Note 2 link
Note 3 link
Note 4 link
Note 5 link
…



Flowsheet Navigation

Problem: flowsheets long, hard to navigate and fill, hard to know where you are

Solution? Use google maps-like navigation frame; automatic cursor focus as one proceeds.



Info transmission + Error/Omission Detection

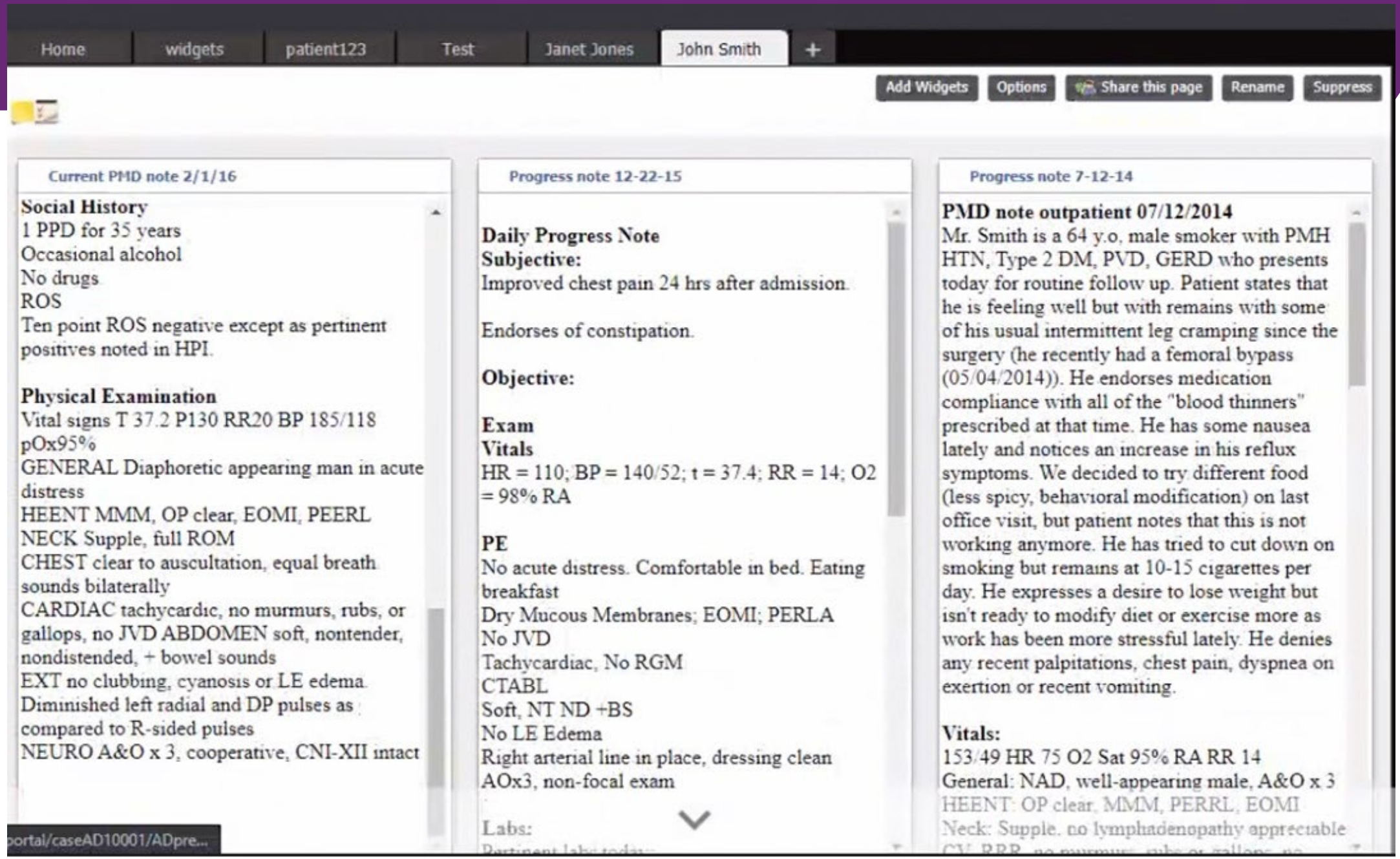
- Default layouts, deliberate error, omission, confusing/contradictory note
- No information distortion in transmission
- **Users either detected and mentioned omissions/errors, or did not mention them but made correct diagnoses** (23/44 case sessions)
  - Was a main objection to this approach

- Times shorter than:
  - User doing composing
  - Conventional EHR review.

Avg Time (sec)	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Composed	420	376	736	434
Conventional	441.4	518.8	828.33	497.5

Crossover Study

- 31 subjects, 4 cases, Latin squares 2x2 crossover study (2 in MedWISER, 2 in commercial ambulatory EHR)
- **Thinkaloud protocol** – user asked to assess case, think aloud, state essential actions, Dx, Tx
- Screen recordings coded for clinical reasoning, UI/UX actions, time on task, debriefing survey


Home
widgets
patient123
Test
Janet Jones
John Smith
+
Add Widgets
Options
Share this page
Rename
Suppress
Current PMD note 2/1/16
Social History
1 PPD for 35 years
Occasional alcohol
No drugs
ROS
Ten point ROS negative except as pertinent positives noted in HPI.
Physical Examination
Vital signs T 37.2 P130 RR20 BP 185/118 pOx95%
GENERAL Diaphoretic appearing man in acute distress
HEENT MMM, OP clear, EOMI, PEERL
NECK Supple, full ROM
CHEST clear to auscultation, equal breath sounds bilaterally
CARDIAC tachycardic, no murmurs, rubs, or gallops, no JVD ABDOMEN soft, nontender, nondistended, + bowel sounds
EXT no clubbing, cyanosis or LE edema
Diminished left radial and DP pulses as compared to R-sided pulses
NEURO A&O x 3, cooperative, CNI-XII intact
Progress note 12-22-15
Daily Progress Note
Subjective:
Improved chest pain 24 hrs after admission.
Endorses of constipation.
Objective:
Exam
Vitals
HR = 110; BP = 140/52; t = 37.4; RR = 14; O2 = 98% RA
PE
No acute distress. Comfortable in bed. Eating breakfast
Dry Mucous Membranes; EOMI; PERLA
No JVD
Tachycardiac, No RGM
CTABL
Soft, NT ND +BS
No LE Edema
Right arterial line in place, dressing clean
AOx3, non-focal exam
Labs:
Progress note 7-12-14
PMD note outpatient 07/12/2014
Mr. Smith is a 64 y.o. male smoker with PMH HTN, Type 2 DM, PVD, GERD who presents today for routine follow up. Patient states that he is feeling well but with remains with some of his usual intermittent leg cramping since the surgery (he recently had a femoral bypass (05/04/2014)). He endorses medication compliance with all of the "blood thinners" prescribed at that time. He has some nausea lately and notices an increase in his reflux symptoms. We decided to try different food (less spicy, behavioral modification) on last office visit, but patient notes that this is not working anymore. He has tried to cut down on smoking but remains at 10-15 cigarettes per day. He expresses a desire to lose weight but isn't ready to modify diet or exercise more as work has been more stressful lately. He denies any recent palpitations, chest pain, dyspnea on exertion or recent vomiting.
Vitals:
153/49 HR 75 O2 Sat 95% RA RR 14
General: NAD, well-appearing male, A&O x 3
HEENT: OP clear, MMM, PERRL, EOMI
Neck: Supple, no lymphadenopathy appreciable
portal/caseAD10001/ADpre...

Chest X-ray 2/1/16

Chest X-ray 2/1/16 Full screen popout

Current PMD note 2/1/16

Admit Note 2/1/16 Pt 10001 John Smith
CC:" Chest pain "

HPI
64 y.o. male smoker with PMH HTN, Type 2 DM, PVD, CAD s/p PCI, GERD was in his usual state of health when he developed sudden chest pain 2 hours prior to initial presentation. He describes the pain as severe, 10/10, sharp/stabbing, localizes it as substernal, radiating to the back. He notes that the pain is exertional and also notes some associated diaphoresis. He denies any SOB but the pain is pleuritic (worse with breathing). He hasn't had similar pain in the past. He denies any recent nausea, vomiting, fever, chills, long flights, recent hospitalizations or operations. He denies any cancer history. He reports taking all medications as prescribed and follows up regularly with his PCP. He took some aleve, but the pain persisted prompting him to come to the ED for further evaluation and pain control.

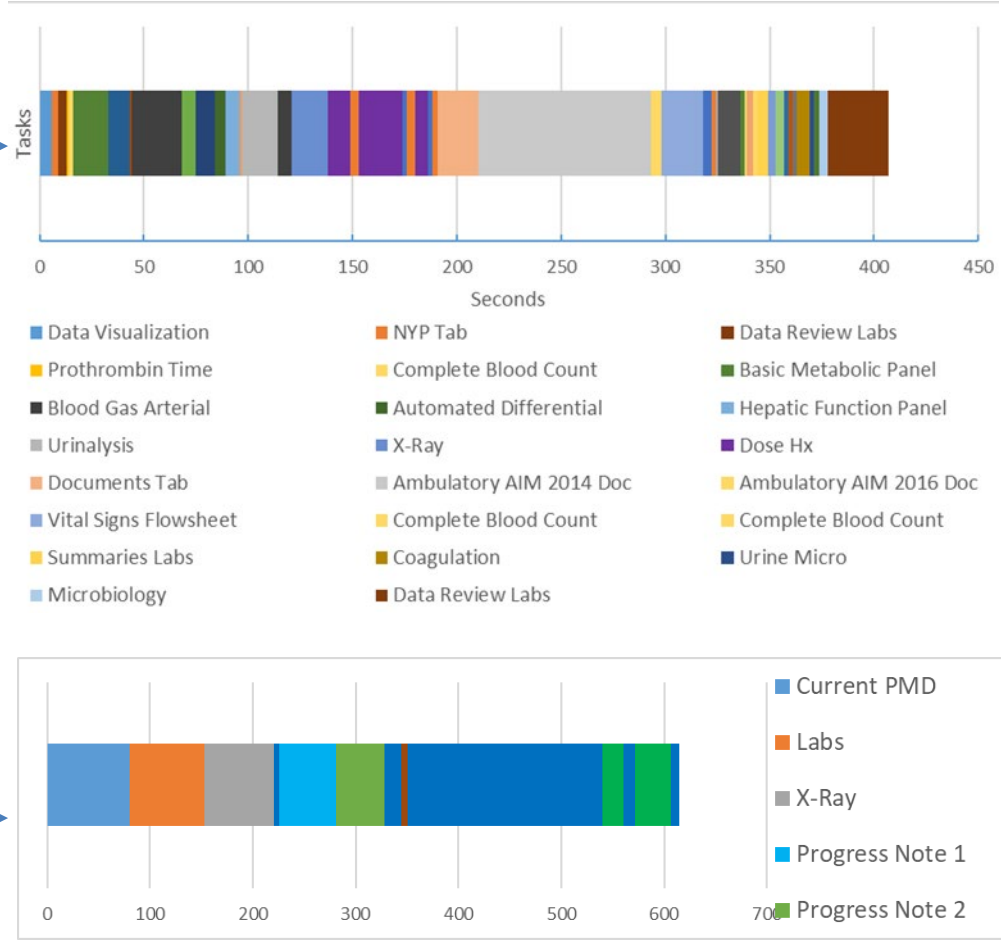
PMedHx
- HTN
- T2DM
- PVD

All labs (with sparklines)

Coagulation profile				
PTT(1)	25		25-35 seconds	
PT(1)	11		10.7 - 15.0 seconds	
INR(1)	0.9		0.8 - 1.1	
CPK				
CPK Total	245		20 - 200 U/L	245
CK MB	5.8		0-5 microgm/L	5.8
CK Index	2.4		0-3	2.4
Troponin(1)	0.03		< 0.4 ng/ml	
d-DIMER(1)	2300		< 500 ng/ml	
Basic metabolic panel				
BUN(2)	12	30	7 - 20 mg/dl	30
K(2)	3.8	3.8	3.7 - 5.2 mmol/L	3.8
Na(2)	139	140	136 - 144 mmol/L	140
Ca(1)		2.5	2.2 - 2.6	

Crossover

- Same case: conventional, composable
- Juxtaposition used for deductions, comparisons
- Direct access to media (e.g., EKG)

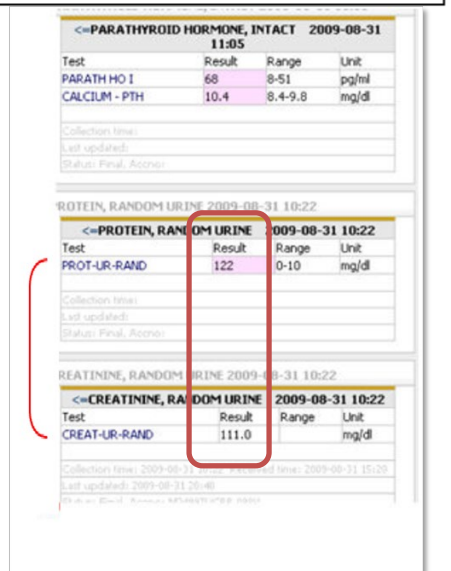


Common Patterns

ORIENTATION

Demographics
condition

current note



DATA

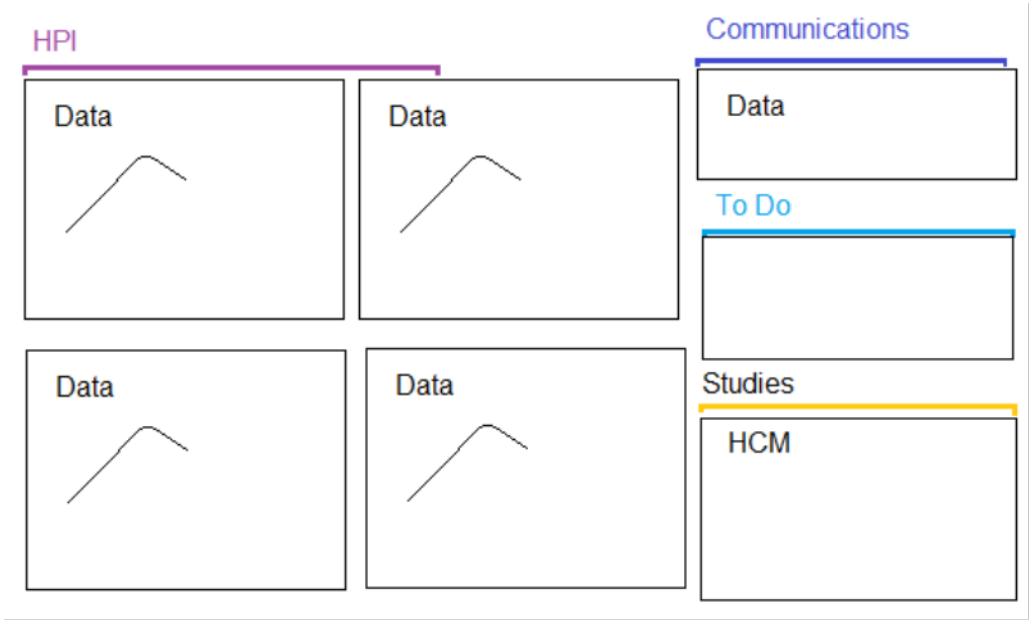
Data

Data

ACTION, COMMUNICATION

medications

HCM



Stated Cognitive/Experience Advantages

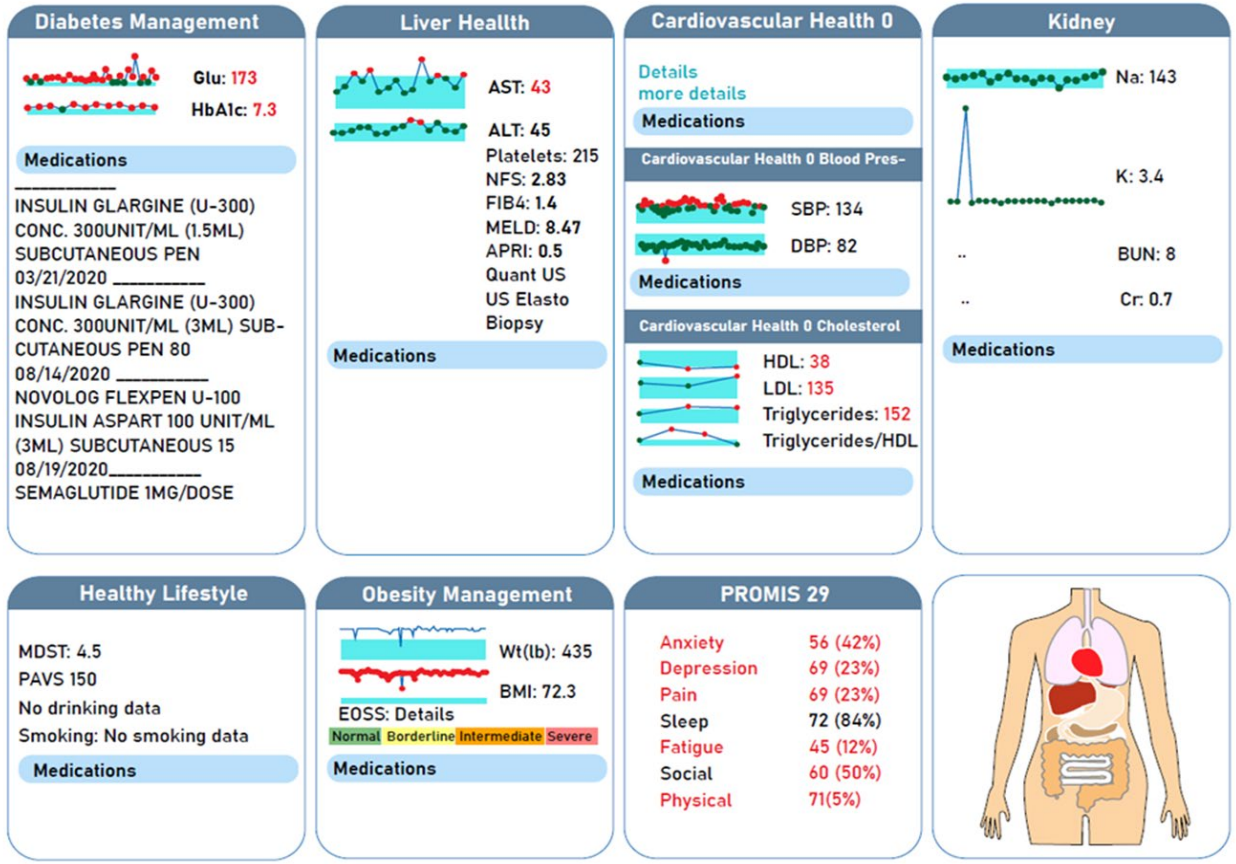
- **See all relevant data together, no disruption in thinking**
- Communication with colleagues and future self informally
  - Unofficial side channel is important
- Jointly standardize what they need
- Visualizations conducive to pattern detection
- Fit to task for clinical reasoning – different than machine predictive delivery
- Time savings
- Checklist effect

5 rights of CDS

- Right information
- Right time
- Right person
- Right channel
- Right format

What if:

- Fast CDS set up?
- Combine CDS AI recommendations + other data rapidly?
- Display patient-reported data with EHR data?



Pros and Cons of Conventional v. Composable

Pros – Conventional	Pros - Composable
• Control by vendor, institution • Large installed base • Common “standard” UI (until upgrade)	• Partial user control (within limits) • Patient-specialty-and content-specific displays • Shared creations • Time efficiency/6x savings • Communication collaboration – common ground displays • Rapid change – meet new needs, safety (suboptimal exposure) • Fit to task, rapid testing • Cognitive support – low display fragmentation • Information exchange; medical knowledge embodied in code • Possible standardization of UI • Lower burden on IT staff • Easily incorporate new 3rd party visualizations, other tools
Cons – Conventional	**Cons – Composable**
• Rigid UI and information selection • Display fragmentation -> cognitive load • Can’t share user work, creations • Cross-user communication may be hard	• New type of system, minimal training required • Conventions may be required in institutional rules • Not necessarily standard or may not be understood • Restriction may be required for specific needs

The Value of Flexible User-Controlled Architecture, Rapid Change

- Resilience – we don't know what new needs arise
  - Pandemic response
    - Covid19 initial – minutes
    - Covid19 with blood clots - 25sec
- Audience – new use cases – most interesting
  - e.g., transitions of care, rapid Covid appraisal, ED decisions/trauma, oncology
- Ease of incorporating new things
  - Visualizations,
  - New AI recommendations (just switch in a tile + add'l requirements)

Senathirajah Y, Bakken S. When Speed is Essential: Rapid Configuration of a User-Configurable 'Web 2.0' Based EHR for H1N1 Decision Support. Proc. of the 5th International Symposium on Human Factors Engineering in Health Informatics, Trondheim, Norway, August 2011.

NASA MCT - Multi-Domain Composition

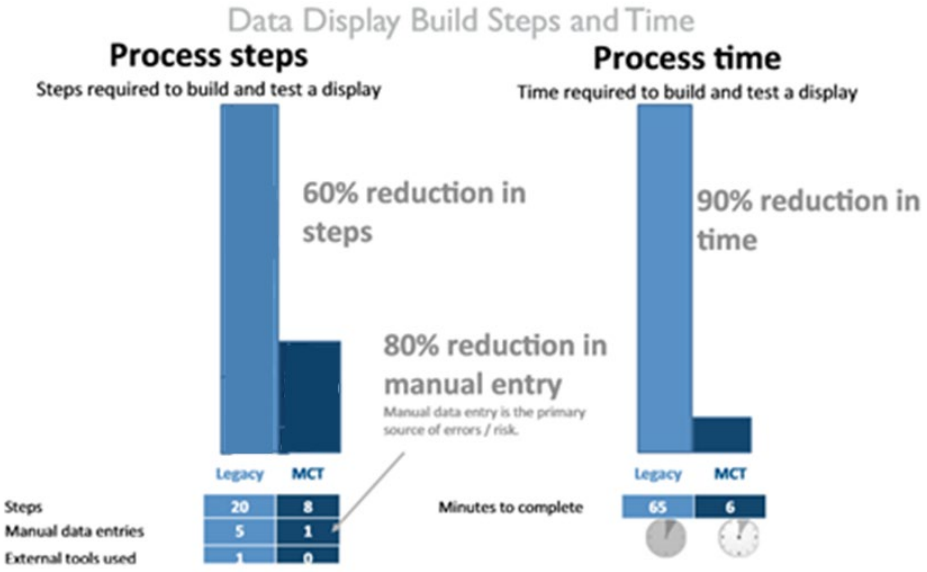


Figure 11. Time and process reduction in display build time measured by one customer

60-90% time/costs reduction

Meets their needs for

- **Reliable extensibility with low risk**
- **components certified →low maintenance /new item costs**
- **fast innovation, fit to user needs**

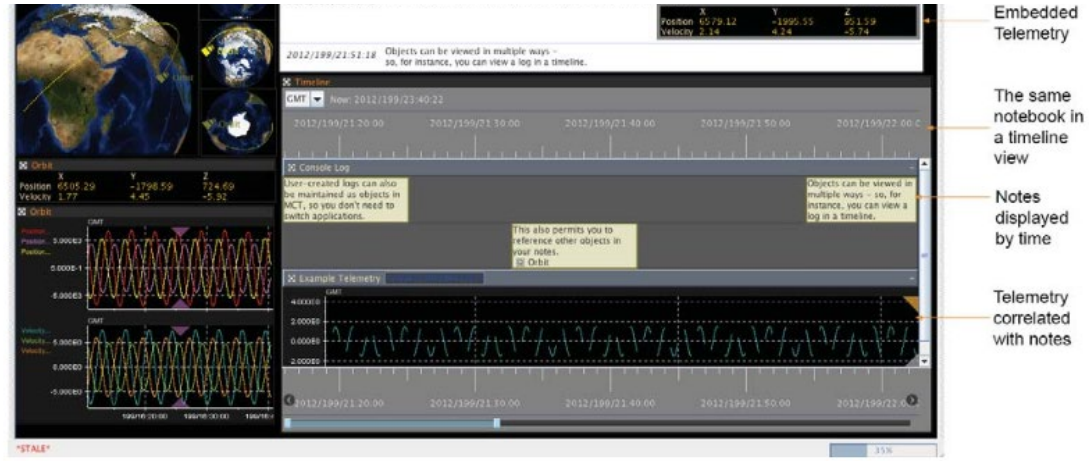


Figure 9. A multi-domain composition showing plots, timelines, logs, orbits, and data correlation over time

Trimble J, et al. A Flexible Evolvable Architecture for Constellation Mission Systems User Applications NASA Ames Research Center
https://ntrs.nasa.gov/api/citations/20090026268/downloads/20090026268.pdf

To Decrease Cognitive Load:

- Juxtapose information used together
- Consider permitting users to have some way to arrange, mark
  - ► Presented as option, not burden
- Shareability
- Left-right pattern of orientation, data, decision/action
- Allow different info types on same page (e.g., Xray + note)
- 3rd party visualizations which aid pattern detection
- **user control may have morale effects, variable use

Wrap Up

- **Looking for collaborations**; esp. those which can implement;
- **Vendors** – if you like these ideas, collaborate with us
- This is a building/usage method - focus on how the whole system works in real work.

For More Info Visit: Ehrlab.org

Stud Health Technol Inform. 2011;169:280-4.

Important ingredients for health adaptive information systems

Yalini Senathirajah [1], Suzanne

Affiliations + expand

PMID: 21893757

Abstract

Healthcare information system
variability, and rapid change in
approaches commonly termed
adaptive architecture. The visio
make all necessary information
for the user to use, arrange, rec
advisable. Clinicians can create
domain knowledge and cater t
intervention of programmers. We have built an example system, MedWISE, embodyin
facing parts of the model. This approach to HIS is expected to have several advantage
greater suitability to user needs (reflecting clinician rather than programmer concepts

Stud Health Technol Inform. 2009;143:315-21.

Architectural and usability considerations in the development of a Web 2.0–based EHR

Yalini Senathirajah [1], Suzanne Bakken

Affiliations + expand

PMID: 19380954

Abstract

In our previous work, we described an electronic healt
principles. With this architecture, users in healthcare a
control the information and interfaces they use by me

5th Human Factors Engineering in Health Informatics Symposium, Trondheim, Norway 2011

When speed is essential: Rapid configuration of a user-configurable 'web 2.0' based EHR for H1N1 decision support

Yalini Senathirajah, David Kaufman, Suzanne Bakken
Columbia University Department of Biomedical Informatics

Abstract

We have proposed that widget-based systems, which allow the user to select, arrange, modify, share, and create clinical and other health information, can have several advantages over conventional systems[1, 2] including better fit with user domain knowledge, integration of clinical and external information, better collaboration and communication, and adaptability to rapid change. We describe a study in which the system was rapidly configured to provide decision support for primary care clinicians treating patients suspected of H1N1 infection, based on emerging guidelines from the Centers for Disease Control (CDC) in the United States.

Acknowledgments & Contact

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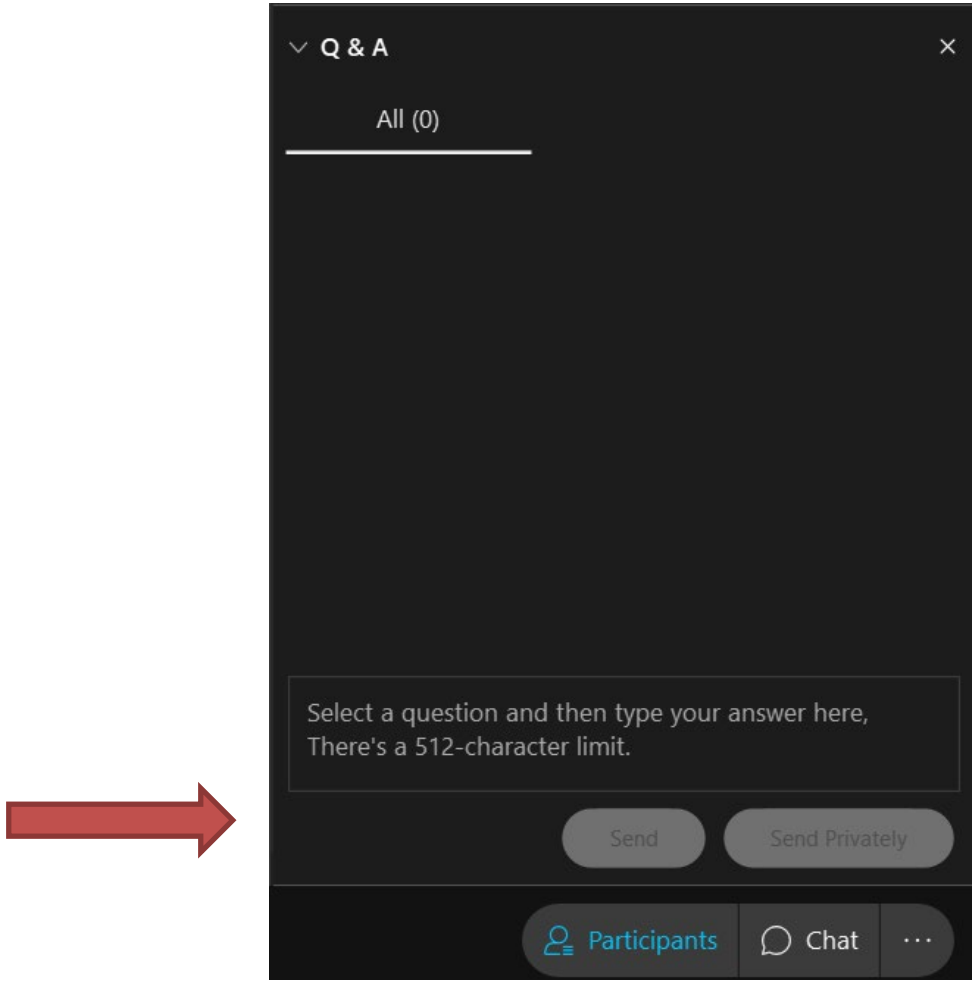

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